U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
PB-294 824

Economic Impact of Implementing RACT Guidelines in the State of Michigan

Booz-Allen and Hamilton, Inc, Bethesda, MD

Prepared for

Environmental Protection Agency, Chicago, IL Region V

Jan 79

PB 294824

United States
Environmental Protection
Agency

Air Programs Branch
230 S. Dearborn St.
Chicago, Illinois 60604

EPA 905/5-78-002
January 1979

Air

EPA

Economic Impact of Implementing RACT Guidelines in the State of Michigan

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA

(Please read instructions on the reverse before completing)

1. REPORT NO. EPA-905/5-78-002	2.	3. RECIPIENT'S ACCESSION NO. PB294824
4. TITLE AND SUBTITLE Economic Impact of Implementing RACT guidelines in the State of Michigan		5. REPORT DATE
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Booz, Allen & Hamilton Inc. Foster D. Snell Division (Florham Park, N.J.) & Public Management Technology Center (Bethesda, MD)		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO. 68-02-2544, Task 3
12. SPONSORING AGENCY NAME AND ADDRESS U.S. Environmental Protection Agency Region V Air Programs Branch Chicago, IL 60604		13. TYPE OF REPORT AND PERIOD COVERED Final Report
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

EPA Project Officer: Rizalino Castanares

16. ABSTRACT

The major objective of the contract effort was to determine the direct economic impact of implementing RACT standards in Michigan. The study is to be used primarily to assist EPA and Michigan decisions on achieving the emission limitations of the RACT standards.

The economic impact was assessed for the following 10 RACT industrial categories: surface coatings (cans, coils, paper, fabrics, insulation of magnet wire, large appliances); solvent metal cleaning; bulk gasoline plants; storage of petroleum liquids in fixed roof tanks; and gasoline dispensing stations--Stage I.

The scope of this project was to determine the costs and direct impact of control to achieve RACT guideline limitations for these 10 industry categories in Michigan. Direct economic costs and benefits from the implementation of RACT limitations were identified and quantified; while secondary impacts (social, energy, employment, etc.) are addressed, they were not a major emphasis in the study.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Gasoline marketing Air pollution Metal coatings Solvent substitution Emission limits	Air pollution control Stationary sources Illinois Economic impact Hydrocarbon emissions Coatings	

18. DISTRIBUTION STATEMENT Unlimited	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 417
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE A18 - A01

EPA Form 2220-1 (9-73)

EPA 905/5-78-002

FINAL REPORT

ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES IN THE STATE OF MICHIGAN

Task Order Number 3 Under:
Basic Ordering Agreement Number 68-02-2544

RESEARCH AND DEVELOPMENT SERVICES FOR ASSISTANCE
TO STATES AND EPA CARRYING OUT REQUIREMENTS
OF CLEAN AIR ACT AND APPLICABLE FEDERAL
AND STATE REGULATIONS

Prepared for:

EPA

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION V
AIR & HAZARDOUS MATERIALS DIVISION
CHICAGO, ILLINOIS 60604

EPA Project Officer: Rizalino Castanares

From:

BOOZ. ALLEN & HAMILTON Inc.

March, 1979

BOOZ
ALLEN

This air pollution report is issued by Region V of the U.S. Environmental Protection Agency (EPA), to assist state and local air pollution control agencies in carrying out their program activities. Copies of this report may be obtained, for a nominal cost, from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22151.

This report was furnished to the EPA by Booz, Allen & Hamilton Inc. in fulfillment of Task Order Number 3 of Basic Ordering Agreement Number 68-02-2544. This report has been reviewed by EPA Region V and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the EPA, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

TABLE OF CONTENTS

CHAPTER	TITLE
1.0	EXECUTIVE SUMMARY
2.0	INTRODUCTION AND OVERALL STUDY APPROACH
3.0	ECONOMIC IMPACT OF IMPLEMENTING RACT FOR CAN MANUFACTURING PLANTS IN THE STATE OF MICHIGAN
4.0	ECONOMIC IMPACT OF IMPLEMENTING RACT TO THE SURFACE COATING OF COILS IN THE STATE OF MICHIGAN
5.0	ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING PAPER IN THE STATE OF MICHIGAN
6.0	ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING FABRICS IN THE STATE OF MICHIGAN
7.0	ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES FOR SURFACE COATING OF AUTOMOBILES (NOT PART OF THIS STUDY)
8.0	ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SURFACE COATING OF METAL FURNITURE (NOT PART OF THIS STUDY)
9.0	ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SURFACE COATING FOR INSULATION OF MAGNET WIRES IN THE STATE OF MICHIGAN
10.0	ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF MICHIGAN
11.0	ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING IN THE STATE OF MICHIGAN

TABLE OF CONTENTS

CHAPTER	TITLE
12.0	ECONOMIC IMPACT OF IMPLEMENTING RACT FOR CONTROL OF REFINERY VACUUM PRODUCING SYSTEMS, WASTEWATER SEPARATORS AND PROCESS UNIT TURNAROUNDS (NOT PART OF THIS STUDY)
13.0	ECONOMIC IMPACT OF IMPLEMENTING RACT FOR TANK TRUCK GASOLINE LOADING TERMINALS (NOT PART OF THIS STUDY)
14.0	ECONOMIC IMPACT OF IMPLEMENTING RACT FOR BULK GASOLINE PLANTS IN THE STATE OF MICHIGAN
15.0	ECONOMIC IMPACT OF IMPLEMENTING RACT FOR STORAGE OF PETROLEUM LIQUIDS IN FIXED-ROOF TANKS IN THE STATE OF MICHIGAN
16.0	ECONOMIC IMPACT OF IMPLEMENTING RACT STAGE I FOR GASOLINE SERVICE STATIONS IN THE STATE OF MICHIGAN
17.0	ECONOMIC IMPACT OF IMPLEMENTING RACT FOR USE OF CUTBACK ASPHALT (NOT PART OF THIS STUDY)

LIST OF EXHIBITS

	Exhibit	Following Page
1-1	LISTING OF EMISSION LIMITATIONS THAT REPRESENT THE PRESUMPTIVE NORM TO BE ACHIEVED THROUGH APPLICATION OF RACT FOR TEN INDUSTRY CATEGORIES	1-7
1-2	SUMMARY OF IMPACT OF IMPLEMENTING RACT GUIDELINES IN 10 INDUSTRIAL CATEGORIES --MICHIGAN	1-8
1-3	ESTIMATED CHANGE IN ENERGY DEMAND RESULTING FROM IMPLEMENTATION OF RACT GUIDELINES IN MICHIGAN	1-11
1-4 - 1-13	SUMMARY EXHIBITS OF THE TEN RACT CATEGORIES	1-17
2-1	LISTING OF EMISSION LIMITATIONS THAT REPRESENT THE PRESUMPTIVE NORM TO BE ACHIEVED THROUGH APPLICATION OF RACT FOR TEN INDUSTRY CATEGORIES	2-5
3-1	DATA QUALITY	3-5
3-2	LIST OF METAL CAN MANUFACTURING FACILITIES POTENTIALLY AFFECTED BY RACT IN MICHIGAN	3-6
3-3	SHEET BASE COATING OPERATION	3-8
3-4	SHEET PRINTING OPERATION	3-8
3-5	CAN END, AND THREE-PIECE BEER AND BEVERAGE CAN FABRICATING OPERATION	3-9
3-6	TWO-PIECE ALUMINUM CAN FABRICATING AND COATING OPERATION	3-10
3-7	EMISSIONS FOR TYPICAL COATING OPERATION USED IN THE MANUFACTURE OF TWO-PIECE CANS	3-10
3-8	COATING AND PRINTING OPERATIONS USED IN THE MANUFACTURE OF THREE-PIECE CANS (Sheet Coating Operation)	3-10
3-9	EMISSIONS OF TYPICAL COATING OPERATIONS USED IN THREE-PIECE CAN ASSEMBLY	3-10

	Exhibit	Following Page
3-10	MICHIGAN EMISSIONS--CAN COATING	3-12
3-11	RACT GUIDELINES FOR CAN COATING OPERATIONS	3-12
3-12	ESTIMATED PERCENTAGE OF CANS TO BE MANUFACTURED IN 1982 USING EACH VOC CONTROL ALTERNATIVE	3-13
3-13	EMISSIONS FROM COATING TWO-PIECE ALUMINUM BEER AND SOFT DRINK CANS PER MILLION CANS	3-18
3-14	EMISSIONS FROM COATING THREE-PIECE CANS PER MILLION CANS	3-18
3-15	COST OF IMPLEMENTING RACT ALTERNATIVES FOR REPRESENTATIVE CAN MANUFACTURING PLANTS ($1,000)	3-19
3-16	COST OF COMPLIANCE TO RACT FOR THE CAN MANUFACTURING INDUSTRY IN MICHIGAN	3-20
3-17	SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR CAN MANUFACTURING PLANTS IN THE STATE OF MICHIGAN	3-23
4-1	SURFACE COATING OF COILS DATA QUALITY	4-4
4-2	DIAGRAM OF A COIL COATING LINE	4-6
4-3	TYPICAL REVERSE ROLL COATER	4-6
4-4	ESTIMATED TONNAGE OF METAL COATED IN THE U.S. IN 1977 WITH COIL COATING TECHNIQUES	4-8
4-5	SUMMARY OF EMISSION CONTROL COSTS	4-9
4-6	COIL COATING OPERATIONS IN ILLINOIS	4-10
4-7	SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR COIL COATING FACILITIES IN THE STATE OF MICHIGAN	4-11
5-1	DATA QUALITY--SURFACE COATING OF PAPER	5-5
5-2	1976 INDUSTRY STATISTICS--SURFACE COATING OF PAPER SIC GROUPS IN MICHIGAN	5-6
5-3	HISTORICAL TRENDS IN VALUE OF SHIPMENTS OF U.S. PLANTS ENGAGED IN PAPER COATING ($ millions)	5-7
5-4	EMISSION DATA FROM TYPICAL PAPER COATING PLANTS	5-9

	Exhibit	Following Page
5-5	TYPICAL PAPER COATING LINE	5-10
5-6	KNIFE COATER	5-10
5-7	REVERSE ROLL COATER	5-11
5-8	COMPANY ESTIMATES OF PAPER COATING EMISSIONS AS REPORTED TO MICHIGAN DEPARTMENT OF NATURAL RESOURCES	5-12
5-9	ACHIEVABLE SOLVENT REDUCTIONS USING LOW SOLVENT COATINGS IN PAPER COATING INDUSTRY	5-13
5-10	INCINERATION COSTS FOR A TYPICAL PAPER COATING OPERATION	5-19
5-11	CARBON ADSORPTION COSTS FOR PAPER COATING INDUSTRY	5-19
5-12	SUMMARY OF ASSUMPTIONS USED IN COST ESTIMATE	5-21
5-13	SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR PAPER COATERS IN THE STATE OF MICHIGAN	5-25
6-1	DATA QUALITY--SURFACE COATING OF FABRICS	6-5
6-2	INDUSTRY STATISTICS FOR PLANTS IN SIC CATEGORIES WHERE FABRIC COATING MAY BE USED IN MICHIGAN	6-6
6-3	FIRMS EXPECTED TO BE AFFECTED BY THE FABRIC COATING RACT REGULATIONS IN MICHIGAN	6-6
6-4	U.S. ANNUAL VALUE OF SHIPMENTS OF COATED FABRICS ($ millions)	6-6
6-5	U.S. ANNUAL SHIPMENTS OF BACKING MATERIALS FOR COATED FABRICS (in millions of pounds)	6-6
6-6	TYPICAL FABRIC COATING OPERATION	6-8
6-7	KNIFE COATING OF FABRIC	6-11
6-8	ROLLER COATING OF FABRIC	6-11
6-9	CAPITAL COST FOR DIRECT FLAME AND CATALYTIC INCINERATORS WITH HEAT EXCHANGE	6-17

Exhibit Following Page

6-10 ANNUAL COST OF DIRECT FLAME INCINERATORS (Primary and secondary heat recovery) 6-17
6-11 SUMMARY OF ASSUMPTIONS USED IN COST ESTIMATE 6-17
6-12 ESTIMATED COSTS OF COMPLIANCE FOR THREE PLANTS IDENTIFIED ($ million) 6-19
6-13 SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR FABRIC COATERS IN THE STATE OF MICHIGAN 6-22
9-1 SURFACE COATING OF MAGNET WIRE DATA QUALITY 9-5
9-2 LIST OF MANUFACTURERS, POTENTIALLY AFFECTED BY RACT GUIDELINES, WHO SURFACE COAT MAGNET WIRE IN MICHIGAN 9-6
9-3 INDUSTRY STATISTICS--SURFACE COATING FOR INSULATION OF MAGNET WIRE IN MICHIGAN 9-6
9-4 COMPARISON OF MAGNET WIRE STATISTICS WITH STATE OF MICHIGAN ECONOMIC DATA 9-6
9-5 HISTORICAL U.S. SHIPMENT FIGURES--MAGNET WIRE INDUSTRY 9-6
9-6 U.S. SHIPMENTS FORECAST FOR MAGNET WIRE INDUSTRY 9-6
9-7 DESCRIPTION OF PRESENT MANUFACTURING TECHNOLOGY FOR MAGNET WIRE 9-7
9-8 DIAGRAM OF A TYPICAL WIRE COATING LINE 9-7
9-9 RACT DATA SUMMARY OF ESTIMATED VOC EMISSIONS FOR SURFACE COATERS FOR INSULATION OF MAGNET WIRE IN MICHIGAN 9-8
9-10 EMISSION LIMITATIONS FOR RACT IN THE SURFACE COATING FOR INSULATION OF MAGNET WIRE 9-8
9-11 SUMMARY OF APPLICABLE CONTROL TECHNOLOGY FOR CONTROL OF ORGANIC EMISSION FROM THE SURFACE COATING FOR INSULATION OF MAGNET WIRE 9-8

	Exhibit	Following Page
9-12	RACT CONTROL OPTIONS FOR THE SURFACE COATING FOR INSULATION OF MAGNET WIRE	9-8
9-13	MOST LIKELY RACT CONTROL ALTERNATIVES FOR SURFACE COATING FOR INSULATION OF MAGNET WIRE IN THE STATE OF MICHIGAN	9-9
9-14	ESTIMATED COSTS FOR ADD-ON CATALYTIC INCINERATION MODIFICATION TO EXISTING MAGNET WIRE COATING LINES TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL	9-10
9-15	STATEWIDE COSTS FOR ADD-ON INCINERATION OF EXISTING MAGENT WIRE COAT LINES TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL MICHIGAN	9-11
9-16	SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURFACE COATING FOR INSULATION OF MAGNET WIRE IN THE STATE OF MICHIGAN	9-13
10-1	SURFACE COATING OF LARGE APPLIANCES DATA QUALITY	10-6
10-2	LIST OF MANUFACTURERS, POTENTIALLY AFFECTED BY RACT GUIDELINES, WHO SURFACE COAT LARGE APPLIANCES IN MICHIGAN	10-7
10-3	INDUSTRY STATISTICS--SURFACE COATING OF LARGE APPLIANCES MICHIGAN	10-7
10-4	COMPARISON OF LARGE APPLIANCE STATISTICS WITH STATE OF MICHIGAN ECONOMIC DATA	10-7
10-5	HISTORICAL U.S. SALES FIGURES--SELECTED MAJOR HOUSEHOLD APPLIANCES FOR 1968-1977	10-8
10-6	FIVE-YEAR U.S. SALES FORECAST FOR SELECTED MAJOR HOUSEHOLD APPLIANCES (1978-1982)	10-8
10-7	PRESENT MANUFACTURING TECHNOLOGY DESCRIPTION	10-9
10-8	DIAGRAM OF A LARGE APPLIANCE COATING LINE	10-9
10-9	RACT DATA SUMMARY FOR ESTIMATED VOC EMISSIONS FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF MICHIGAN	10-10

	Exhibit	Folowing Page
10-10	EMISSION LIMITATIONS FOR RACT IN THE SURFACE COATING OF LARGE APPLIANCES	10-10
10-11	SUMMARY OF APPLICABLE CONTROL TECHNOLOGY FOR COATING OF LARGE APPLIANCE DOORS, LIDS, PANELS, CASES AND INTERIOR PARTS	10-10
10-12	RACT CONTROL OPTIONS FOR THE LARGE APPLIANCE INDUSTRY	10-10
10-13	MOST LIKELY RACT CONTROL ALTERNATIVES FOR SURFACE COATING OF LARGE APPLIANCES IN MICHIGAN	10-11
10-14	ESTIMATED COST FOR PROCESS MODIFICATION OF EXISTING LARGE APPLIANCE COATING LINES TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL	10-12
10-15	STATEWIDE COSTS FOR PROCESS MODIFICATIONS OF EXISTING LARGE APPLIANCE COATING LINES TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL MICHIGAN	10-13
10-16	SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF MICHIGAN	10-17
11-1A	DATA QUALITY	11-10
11-1	ESTIMATED NUMBER OF VAPOR DEGREASERS IN MICHIGAN	11-11
11-2	ESTIMATED NUMBERS OF COLD CLEANERS IN MICHIGAN	11-11
11-3	ESTIMATE OF NONEXEMPT SOLVENT METAL CLEANERS IN MICHIGAN	11-11
11-4	SOLVENTS CONVENTIONALLY USED IN SOLVENT METAL DEGREASING	11-12
11-5	CONTROL SYSTEMS FOR COLD CLEANING	11-16
11-6	EPA PROPOSED CONTROL SYSTEMS FOR OPEN TOP VAPOR DEGREASERS	11-16
11-7	EPA PROPOSED CONTROL SYSTEMS FOR CONVEYORIZED DEGREASERS	11-16
11-8	AVERAGE UNIT EMISSION RATES AND EXPECTED EMISSION REDUCTIONS	11-19

	Exhibit	Following Page
11-9	ESTIMATED CURRENT AND REDUCED EMISSIONS FROM SOLVENT METAL CLEANING IN MICHIGAN (Tons/Year)	11-19
11-10	CONTROL COSTS FOR COLD CLEANER WITH 5.25 FT.^{2} AREA	11-20
11-11	CONTROL COSTS FOR AVERAGE-SIZED OPEN TOP VAPOR AND CONVEYORIZED CLEANERS	11-20
11-12	ESTIMATED CONTROL COSTS FOR COLD CLEANERS FOR THE STATE OF MICHIGAN	11-20
11-13	ESTIMATED CONTROL COSTS FOR OPEN TOP VAPOR DEGREASERS FOR THE STATE OF MICHIGAN	11-20
11-14	ESTIMATED CONTROL COSTS FOR CONVEYORIZED DEGREASERS FOR THE STATE OF MICHIGAN	11-20
11-15	ESTIMATED NUMBER OF COLD CLEANERS NEEDING CONTROLS IN THE STATE OF MICHIGAN	11-20
11-16	ESTIMATED NUMBER OF OPEN TOP VAPOR DEGREASERS NEEDING CONTROL IN THE STATE OF MICHIGAN	11-20
11-17	ESTIMATED NUMBER OF CONVEYORIZED DEGREASERS NEEDING CONTROLS IN THE STATE OF MICHIGAN	11-20
11-18	SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING IN THE STATE OF MICHIGAN	11-23
14-1	DATA QUALITY	14-5
14-2	INDUSTRY STATISTICS FOR BULK GASOLINE PLANTS IN MICHIGAN	14-6
14-3	GASOLINE DISTRIBUTION NETWORK	14-6
14-4	DISTRIBUTION OF BULK GASOLINE PLANTS BY AMOUNT OF THROUGHPUT	14-7
14-5	VOC EMISSIONS FROM BULK GASOLINE PLANTS IN MICHIGAN	14-9
14-6	VOC EMISSION CONTROL TECHNOLOGY FOR BULK GASOLINE PLANTS	14-10
14-7	ALTERNATIVE CONTROL METHODS FOR VAPOR CONTROL AT BULK GASOLINE PLANTS	14-11

Exhibit		Following Page
14-8	COSTS OF ALTERNATIVE VAPOR CONTROL SYSTEMS	14-13
14-9	DESCRIPTION AND COST OF MODEL BULK PLANTS EQUIPPED WITH VAPOR CONTROL SYSTEMS	14-14
14-10	STATEWIDE COSTS OF VAPOR CONTROL SYSTEMS FOR BULK GASOLINE PLANTS	14-15
14-11	STATEWIDE COSTS OF VAPOR CONTROL SYSTEM BY SIZE OF BULK GASOLINE PLANT	14-15
14-12	SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR BULK GASOLINE PLANTS IN THE STATE OF MICHIGAN	14-21
15-1	DATA QUALITY	15-4
15-2	TYPICAL FIXED ROOF TANK	15-5
15-3	SCHEMATIC OF TYPICAL FIXED-ROOF TANK WITH INTERNAL FLOATING COVER	15-6
15-4	TYPICAL FLOTATION DEVICES AND PERIMETER SEALS FOR INTERNAL FLOATING COVERS AND COVERED FLOATING ROOF	15-7
15-5	INSALLED COST OF SINGLE SEAL FLOATING ROOF TANKS (Prices Approximate)	15-9
15-6	VOC EMISSIONS CONTROL COSTS FOR STORAGE OF PETROLEUM LIQUIDS IN FIXED-ROOF TANKS IN MICHIGAN	15-9
15-7	SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR STORAGE OF PETROLEUM LIQUIDS IN THE STATE OF MICHIGAN	15-10
16-1	DATA QUALITY	16-4
16-2	INDUSTRY STATISTICS FOR GASOLINE SERVICE STATIONS IN MICHIGAN	16-5
16-3	GASOLINE DISTRIBUTION NETWORK	16-6
16-4	CLASSIFICATION OF SERVICE STATIONS	16-6
16-5	VOC EMISSIONS FROM GASOLINE SERVICE STATIONS	16-9

	Exhibit	Following Page
16-6	VOC EMISSION CONTROL TECHNOLOGY FOR GASOLINE SERVICE STATIONS	16-10
16-7	STAGE I VAPOR CONTROL SYSTEM - VAPOR BALANCING WITH SEPARATE LIQUID-VAPOR RISERS	16-10
16-8	STAGE I VAPOR CONTROL SYSTEM - VAPOR BALANCING WITH CONCENTRIC LIQUID-VAPOR RISERS	16-10
16-9	STAGE I VAPOR CONTROL COSTS FOR A TYPICAL GASOLINE SERVICE STATION	16-13
16-10	STATEWIDE COSTS FOR STAGE I VAPOR CONTROL OF GASOLINE SERVICE STATIONS	16-14
16-11	STATEWIDE COSTS OF VAPOR CONTROL SYSTEMS BY SIZE OF GASOLINE DISPENSING FACILITY IN MICHIGAN	16-14
16-12	SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR GASOLINE SERVICE STATIONS IN THE STATE OF MICHIGAN	16-18

LIST OF FIGURES

11-1	TYPICAL COLD CLEANER	11-13
11-2	TYPICAL OPEN TOP VAPOR DEGREASER	11-14
11-3	TYPICAL CONVEYORIZED DEGREASER	11-15

1. EXECUTIVE SUMMARY

1. EXECUTIVE SUMMARY

This chapter summarizes the major elements and most significant findings of the study to determine the economic impact of implementing Reasonably Available Control Technology (RACT) guidelines for volatile organic compounds in the state of Michigan. Further discussion and data are presented in detail in the subsequent chapters of the report. This Executive Summary is divided into three sections:

- Objectives, Scope and Approach
- Statewide Aggregate Economic Impact for the Ten RACT Guidelines
- Economic Implications of Each RACT Guideline.

1.1 OBJECTIVES, SCOPE AND APPROACH

1.1 OBJECTIVES, SCOPE AND APPROACH

The Clean Air Act Amendments of 1977 required the states to revise their State Implementation Plans (SIPs) to provide for the attainment and maintenance of national ambient air quality standards in areas designated as nonattainment. The Amendments require that each state submit the SIP revisions to the U.S. Environmental Protection Agency (EPA) by January 1, 1979. These proposed regulations should contain an oxidant plan submission for major urban areas to reflect the application of Reasonably Available Control Technology (RACT) to stationary sources for which the EPA has published guidelines. The Amendments also require that the states identify and analyze the air quality, health, welfare, economic, energy and social effects of the plan provisions.

1.1.1 Objectives

The major objective of the contract effort was to determine the direct economic impact of implementing RACT standards for industrial categories in four states (Illinois, Wisconsin, Ohio and Michigan) of Region V of the U.S. Environmental Protection Agency. These studies will be used primarily to assist EPA and state decisions on achieving the emission limitations of the RACT standards.

1.1.2 Scope

The scope of this project was to determine the costs and direct impacts of control to achieve RACT guideline limitations. The impact was addressed for each industry and for each state so that the respective studies are applicable to individual state regulations. Direct economic costs and benefits from the implementation of the RACT guidelines were identified and quantified. While secondary (social, energy, employment, etc.) impacts were addressed, they were not a major emphasis in the study. In summary, direct economic impact analysis of each industrial category was aggregated on a statewide basis for the RACT categories studied.

- In Michigan, the economic impact was assessed for the following ten RACT industrial categories:

  - Surface coating of cans
  - Surface coating of coils
  - Surface coating of paper
  - Surface coating of fabrics

  - Surface coating for insulation of magnet wire
  - Surface coating of large appliances
  - Solvent metal cleaning
  - Bulk gasoline plants
  - Storage of petroleum liquids in fixed roof tanks
  - Service stations--Stage I.

- Five additional RACT industrial categories were studied for the states of Illinois, Ohio and Wisconsin, but were not assessed for Michigan. These are:

  - Surface coating of automobiles and light duty trucks
  - Surface coating of metal furniture
  - Bulk gasoline terminals
  - Refinery vacuum producing systems, wastewater separators and process unit turnarounds
  - Use of cutback asphalt.

In the determination of the economic impact of the RACT limitations, the following are the major study guidelines:

- The emission limitations for each industrial category were studied at the control level established by the RACT guidelines. These are presented in Exhibit 1-1, at the end of this section.

- The timing requirement for implementation of controls to meet RACT emission limitations was January 1, 1982.

- All costs and emission data were presented for 1977.

- Emission sources included were existing stationary point sources in most of the applicable industrial categories with VOC emissions greater than 3 pounds in any hour or 15 pounds in any day.[1]
- The following volatile organic compounds were exempted:
  - Methane
  - Ethane
  - Trichlorotrifluorethane (Freon 113)
  - 1,1,1-trichloroethane (methyl chloroform).[2]
- The cost of compliance was determined from the current level of control (i.e., if an affected facility already had control in place, the cost of compliance and the resulting VOC emissions reduction are not included in this analysis).

1.1.3 Approach

The approach applied to the overall study was: a study team with technology and economic backgrounds utilized available secondary sources to estimate the emissions, statistics and costs for each RACT industrial category; then, the study team completed, calibrated and refined these estimates based on approximately 60 interviews with a cross-section of industry representatives in the four states. Because of the number of point sources and the data available in the state emission inventory, the methodology was specific for each RACT industrial category studied. However, the general methodology applied for two major classes of industrial categories was:

- Surface coating RACT industrial categories (cans, coils, fabrics, paper, magnet wire and large appliances)--the potentially affected facilities, emissions and emission characteristics were obtained from the state emission inventory. Therefore, the following generalized methodology was applied:
  - A list of potentially affected facilities was compiled from secondary reference sources.

---

[1] For some industrial categories (such as solvent metal cleaning and fixed roof tanks) size characteristics are used as the basis for inclusion, rather than emissions.

[2] The exemption status of methyl chloroform under these guidelines may be subject to change.

  - Data from the emission inventory were categorized and compiled for each RACT industrial category.
  - Firms not listed in the emission inventory were identified. A few of these facilities were then interviewed by telephone when there was doubt concerning their inclusion.
  - Emissions, emission characteristics, control options and control costs were studied for relevant firms.
  - Interviews were conducted to determine applicable control options and potential control costs.
  - The study team then evaluated the control cost to meet the RACT requirements and the potential emission reduction.

- Nonsurface coating RACT industrial categories (bulk gasoline plants, service stations, fixed roof tanks and solvent metal cleaning)--each category represented an exhaustive list of potentially affected facilities and, in general, emissions data were not available (or categorized) for these types of sources. Therefore, the following generalized methodology was applied:

  - Industry statistical data were collected from secondary reference sources.
  - Statewide emissions were estimated by applying relevant factors (e.g., emissions per facility or throughput).
  - Control options and estimated costs to meet the RACT guidelines were reviewed.
  - Interviews were conducted to determine applicable associated control options and the cost of control.

1.1.4 Quality of Estimates

The quality of the estimates that are presented in this report can be judged by evaluating the basis for estimates of the individual study components. In each of the chapters that deal with the development of estimated compliance cost, the sources of information are fully documented.

In the determination of the economic impact for each industrial category studied, the estimated compliance cost is subject to variations due to inherent variations in procedures for estimating:

- Engineering costs
- The number of sources affected.

Engineering cost estimates, when performed for an individual modification with specific equipment sized at the desired capacity, are typically subject to variations of 25 percent. When engineering cost estimates are performed on technologies not commercially proven for a specific facility, the variations are much greater, many times over 100 percent.

Many of the RACT categories studied (such as solvent metal cleaning) represent an exhaustive list of potentially affected facilities that have not been previously identified or categorized. Therefore, the actual number of facilities affected by a given RACT industrial category had to be estimated from available data sources.

If a study with unlimited resources were performed, to estimate the specific cost to each individual facility affected within the state, the study would be subject to a 25 percent to 50 percent variation because of the inherent variability of engineering estimates and the uncertainty involved in the selection and demonstrated capabilities of the control alternatives. Furthermore, a study of this type would take years to perform.

Therefore, to put a perspective on the estimates presented in this report, the study team has categorically ranked by qualitative judgment the overall data quality of the major sources and, therefore, of the outcomes. These data quality estimates were ranked into three categories:

- High quality ("hard data")--study inputs with variation of not more than ± 25 percent.

- Medium quality ("extrapolated data")--study inputs with variation of ± 25 to ± 75 percent.

- Low quality ("rough data")--study inputs with variation of ± 50 to ± 150 percent.

Each of these data quality estimates is presented in the individual chapters. The overall quality ranking of the study inputs for each RACT industrial category was generally in the medium quality range.

EXHIBIT 1-1 (1)
U.S. Environmental Protection Agency
LISTING OF EMISSION LIMITATIONS THAT REPRESENT THE PRESUMPTIVE NORM TO BE ACHIEVED THROUGH APPLICATION OF RACT FOR TEN INDUSTRY CATEGORIES

Category	RACT Guideline Emission Limitations[a] Surface Coating Categories Based on Low Organic Solvent Coatings (lbs. solvent per gallon of coating, minus water)
Surface Coating Of:	
Cans	2.8
. Sheet basecoat (exterior and interior) Overvarnish Two-piece can exterior (basecoat and overvarnish)	
. Two and three-piece can interior body spray Two-piece can exterior end (spray or rollcoat)	4.2
. Three-piece can side-seam spray	5.5
. End sealing compound	3.7
Coils	
. Prime and topcoat or single coat	2.6
Paper	2.9
Fabrics and vinyl coating	
. Fabric	2.9
. Vinyl	3.8
Magnet Wire	1.7
Large appliance	
. Prime, single or topcoat	2.8
Solvent Metal Cleaning	
. Cold cleaning	Provide cleaners with: cover; facility to drain clean parts; additional free-board; chiller or carbon absorber. Follow suggested procedures to minimize carryout
. Conveyorized degreaser	Provide cleaners with: refrigerated chillers; or carbon adsorption system; drying tunnel or rotating basket; safety switches, covers. Follow suggested procedures to minimize carryout
. Open top degreaser	Provide cleaner with: safety switches; powered cover; chiller; carbon absorber. Follow suggested procedures to minimize carryout
Bulk Gasoline Plants	Provide submerged filling and vapor balancing so that VOC emissions from control equipment do not exceed 80 miligrams per liter (4.7 grains per gallon) of gasoline loaded

EXHIBIT 1-1 (2)
U.S. Environmental Protection Agency

Category	RACT Guideline Emission Limitations[a]
Storage of Petroleum Liquids in Fixed Roof Tanks	Provide single seal and internal floating roof to all fixed roof storage vessels with capacities greater than 150,000 liters (39,000 gal.) containing volatile petroleum liquids for which true vapor pressure is greater than 10..5 kilo Pascals (1.52 psia)
Service Stations (Stage I)	Provide submerged fill and vapor balance for any stationary storage tank located at a gasoline dispensing facility

---

a. Annotated description of RACT guidelines

Source: Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, U.S. Environmental Protection Agency, EPA-905/2-78-001, April 1978.

1.2 STATEWIDE AGGREGATE ECONOMIC IMPACT FOR THE TEN RACT GUIDELINES

1.2 STATEWIDE AGGREGATE ECONOMIC IMPACT FOR THE TEN RACT GUIDELINES

The implementation of RACT emission limitations for ten industrial categories in Michigan involves an estimated $78 million capital cost and $17.2 million annualized cost per year. The net VOC emission reduction is estimated to be 72,500 tons annually. Exhibit 1-2, on the following page, presents a quantitative summary of the emissions, estimated cost of control, cost indicators and cost effectiveness of implementing RACT guidelines for ten industrial categories.

- Approximately 29,600 facilities are potentially affected by the ten RACT guidelines in Michigan.
  - More than 96 percent of the potentially affected facilities are represented by the solvent metal cleaning (15,400 cleaning operations) and service station (13,570 facilities) industrial categories.
  - Less than 1 percent (59 facilities) of the potentially affected facilities are represented by the six surface coating industrial categories (cans, coils, paper, fabrics, magnet wire and large appliances).
- In 1977, the estimated annual VOC emissions (including those already controlled) for the ten RACT industrial categories totalled approximately 141,800 tons.
  - Solvent metal cleaning represented 30 percent of the total VOC emissions (from the ten RACT categories studied)
  - Two gas marketing categories (bulk gas plants and service stations) represented 43 percent of the total VOC emissions
  - Fixed roof tanks represented 14 percent of the total VOC emissions
  - Six surface coating categories represented 13 percent of the total VOC emissions.

EXHIBIT 1-2
U.S. Environmental Protection Agency
SUMMARY OF IMPACT OF IMPLEMENTING RACT
GUIDELINES IN 10 INDUSTRIAL CATEGORIES -- MICHIGAN

	Emissions				Cost of RACT Control		Cost Indicators		Cost Effectiveness
Industry Category	Number of Facilities Potentially Affected	1977 VOC Emissions (tons/yr.)	Estimated VOC Emissions after Implementing RACT (tons/yr.)	Net VOC Emission Reductions (tons/yr.)	Capital Cost[a] ($ millions)	Annualized Cost ($ millions)	Annualized Cost as Percent of Value of Shipments[b] (percent)	Annualized Cost Per Unit Shipment (cost per unit)	Annualized Cost Per Ton of VOC Reduction ($ per tons/yr.)
Surface coating of cans	6	900	200	700	0.4	0.2	0.14	$0.0001/can	225
Surface coating of coils	4	400	150	250	0.3	0.1	NA	NA	300
Surface coating of fabrics	3	3,000	450	2,550	5.6	1.5	1.0	NA	650
Surface coating of paper	30	13,000	2,500	10,500	14.5	4.0	1.3	NA	375[e]
Surface coating for insulation of magnet wire	4	277	35	242	1.5[d]	0.2[d]	1.5[d]	$0.02/pound of wire[d]	1,000[de]
Surface coating of large appliances	12	1,000	300	700	4.8	1.1	0.08	$0.20/household appliances	1,576
Solvent metal cleaning	15,000	42,500	32,500	10,000	5.9	0.7	<0.03	NA	70
Bulk gasoline plants	800	15,400	4,000	11,400	12.4	3.3	0.6	$0.0025/gal.[c]	290
Storage of petroleum liquids in fixed roof tanks	160	20,400	2,000	18,400	20	3.1	NA	NA	170
Service Stations (Stage I)	13,570	45,000	27,200	17,800	12.9	3.0	0.12	<$0.0008/gal.	170
TOTALS	29,600	141,800	69,300	72,500	78.3	17.2			

Note: Figures presented in this exhibit are rounded and approximated for comparison purposes.

a. Includes one time costs
b. Value of shipments represents the total value in the specific industry category for the state being studied.
c. This represents the industrywide increase; small operations will be subject to a $0.005 to $0.01 gallon increase.
d. These figures could be significantly higher if waterborne coating technology is not developed for specific applications.
e. These numbers are averages.

.rce: z, & Ha n In

- The net emission reduction achievable by implementing the ten RACT guidelines is estimated to be 72,500 tons annually. The approximate percent of the total VOC emissions reduced by implementing RACT by industrial category group is:
    - Gas marketing categories--40 percent of VOC emission reduction
    - Fixed roof tanks--25 percent of VOC emission reduction
    - Surface coating categories--21 percent of VOC emission reduction
    - Solvent metal cleaning--14 percent of VOC emission reduction.
- The capital cost for the ten industrial categories to achieve the RACT guidelines is estimated to be \$78.3 million. The three industrial categories dealing with petroleum (bulk gasoline plants, service stations and fixed roof tanks) account for approximately \$45 million (or 58 percent of the total) of the estimated capital cost.
- The annualized cost for the ten RACT industrial categories to achieve the RACT guidelines is estimated to be \$17.2 million. In terms of cost indicators, the annualized compliance cost per value of shipments will have the largest effect on the following industrial categories:
    - Paper coating--The annualized costs represent approximately 1.3 percent of the 1977 statewide value of shipments.
    - Surface coating of fabrics--The annualized compliance costs represent approximately 1.0 percent of the 1977 statewide value of shipments.
    - Bulk gasoline plants--The annualized costs represent approximately 0.6 percent of the 1977 statewide value of shipments.

- Technology developments and delivery of equipment could present problems in achieving the 1982 timing requirements of the RACT guidelines.
    - Low solvent coating technology requires further development for cost- and energy-effective implementation of the RACT guidelines in the following industrial categories:
        - Surface coating of large appliances
        - Surface coating of cans (end sealing compound)
        - Surface coating of paper and fabrics.
    - Equipment delivery and installation of control equipment were identified as potential problems in the following industrial categories.
        - Surface coating of paper
        - Solvent metal degreasing
        - Bulk gasoline plants
        - Surface coating of fabrics
        - Storage of petroleum liquids
        - Gasoline service stations.
- With the exception of bulk gasoline plants, the implementation of the RACT guidelines are not expected to have major impacts on statewide productivity and employment. Capital cost requirements for bulk gasoline plants could further concentrate a declining industry. Many small bulk plants today are marginal operations and further cost increases may result in some plant closings.
- The implementation of the RACT guidelines is expected to create further concentration for industrial sectors requiring major capital and annualized cost increases for compliance. RACT requirements may have an impact on the market structure of the following RACT industrial categories:
    - Bulk gasoline plants
    - Service stations
    - Surface coating of paper
    - Surface coating of fabrics.

- The implementation of the RACT guidelines for the ten industrial categories is estimated to represent a net energy savings of 280,000 equivalent barrels of oil annually; or 0.25 percent of the statewide energy demand for all manufacturing. Assuming a value of oil at $13 per barrel, this is an equivalent energy savings of $3.66 million annually. Exhibit 1-3, on the following page, presents the estimated change in energy demand from implication of the RACT guidelines in Michigan.
  - RACT compliance requirements for the six surface coating industrial categories (cans, coil, paper, fabrics, insulation of magnet wire and large appliances) represent a net energy demand of approximately 60,000 equivalent barrels of oil annually.
  - RACT compliance requirements for the three industrial categories dealing with petroleum marketing (service stations, fixed roof tanks and bulk gasoline plants) represent a net energy savings of approximately 340,000 barrels of oil annually. However, the technical feasibility of control efficiency has not been demonstrated and these estimates are likely to overstate the achievable energy savings for bulk gasoline plants and service stations.

In 1977, the statewide value of shipments of the ten industrial categories potentially affected by RACT was $4.8 billion, which represents approximately 5 percent of Michigan's total value of shipments of manufactured goods. The estimated annualized cost of implementing the RACT guidelines ($17.2 million) represents 0.37 percent of the value of shipments for the ten RACT industrial categories affected. The annualized cost represents 0.019 percent of the statewide total value of shipment of all manufactured goods.

EXHIBIT 1-3
U.S. Environmental Protection Agency
ESTIMATED CHANGE IN ENERGY DEMAND RESULTING FROM IMPLEMENTATION OF RACT GUIDELINES IN MICHIGAN

Industry Category	Energy Demand Change Increased (Decrease)[a] (Equivalent barrels of oil)	Energy Demand Change Cost/Savings ( )[b] ($ million)
Surface coating of cans	3,250	0.04
Surface coating of coils	NA	NA
Surface coating of paper	55,000	0.72
Surface coating of fabrics	14,000	0.18
Surface coating of insulation of magnet wire	(10,000)	(0.12)
Surface coating of large appliances	(2,400)	(0.03)
Solvent metal cleaning	negligible	negligible
Bulk gasoline plants	(78,000)	(1.01)
Storage of petroleum liquids in fixed roof tanks	(140,000)	(1.85)
Service stations (STAGE I)	(122,000)	(1.59)
TOTAL	(280,150)	(3.66)

---

a. Based on the assumption of 6 million BTU's per equivalent barrel of oil.
b. Based on the assumption that the cost of oil is $13 per barrel.

Source: Booz, Allen & Hamilton Inc.

1.3 ECONOMIC IMPLICATIONS OF EACH RACT GUIDELINE

1.3 ECONOMIC IMPLICATIONS OF EACH RACT GUIDELINE

This section presents a summary of the economic impact for each of the ten RACT industrial categories studied. Following this section is a series of summary exhibits which highlight the study findings for each industrial category.

1.3.1 Surface Coating of Cans

Currently the five can coaters in the state of Michigan manufacture only three-piece cans. This product mix is unusual for the can manufacturing industry, since the industry has rapidly been converting to two-piece can construction.

The industry-preferred method of control to meet the RACT requirements is to convert to low solvent (waterborne) coatings. However, low solvent coatings for end sealing compounds are presently not available and may not be available by 1982. To meet the RACT requirements, can manufacturers in Michigan may face relatively higher capital investment than the can manufacturing industry in general to convert facilities to two-piece can lines (where commercially feasible) and install thermal incineration facilities for controlling high solvent coatings. It is also possible that precoated stock will be manufactured out of state for cost-effectiveness, in addition to meeting RACT requirements. Emission controls are expected to cost $400,000-$500,000 in capital and $150,000-$200,000 (approximately 0.14 percent of statewide industry value of shipments) in annualized costs to meet RACT guidelines. Assuming a "direct cost pass-through," a price increase of less than $0.0002 per can is anticipated (based on can value of $0.085 per can).

1.3.2 Surface Coating of Coils

Of the four facilities identified as coil coaters and subject to the RACT guidelines, three have implemented controls and are assumed to meet the RACT guidelines. The fourth firm's coil coating operation provides the entire company's captive aluminum requirements. The line is reported to be noncompetitive in today's environment and there is some question as to its commercial viability even without the requirements to install an emission control system. Therefore, on a statewide basis, the net effect of the RACT requirements will be minimal, in terms of both cost and emissions controlled.

1.3.3 Surface Coating of Paper

This study covered 30 plants identified from the state emission inventory. Excluded from this study are facilities engaged in publishing, who may coat paper as a segment of the processing line. The study assumes that these facilities would fall under other RACT guidelines currently being developed. Further definition of the paper coating category needs to be established prior to regulatory enforcement.

The retrofit situations and installation costs for add-on controls are highly variable. Based on these variations, the estimated capital cost to the industry is between $13 million and $16 million, with an annualized cost of $3.2 million to $4.7 million (approximately 1.3 percent of the statewide industry value of shipments). Some smaller firms have indicated they may not be able to secure the necessary capital funding for add-on systems. The effect on employment will be a function of the number of firms that may cease operations.

Assuming 35 percent heat recovery, the annual energy requirements are expected to increase by approximately 55,000 equivalent barrels of oil per year. Energy consumption may decrease if further efficient recovery of incinerator heat is possible.

1.3.4 Surface Coating of Fabrics

There are three firms in Michigan identified as coaters of fabric and affected by the proposed RACT guidelines. These facilities will be required to invest an estimated $4.8 million to $6.4 million in capital and approximately $1.5 million (approximately 1.0 percent of statewide industry value of shipments) in annualized cost to meet RACT limitations. The companies affected estimated their capital costs at closer to $10 million.

No significant productivity, employment or market structure dislocations should be associated with the implementation of the RACT guideline.

Incinerator equipment manufacturers have stated that there may be significant problems in meeting the anticipated demand for high heat recovery incinerators.

Assuming a 70 percent heat recovery, about 14,000 barrels of additional fuel oil per year would be required to operate the control equipment.

1.3.5 Surface Coating for Insulation of Magnet Wire

There are four firms in Michigan identified as coaters of magnet wire and potentially affected by the RACT guidelines. Two of these firms will have installed afterburners on all ovens by the end of the year; therefore, for purposes of this analysis, it is assumed these facilities meet the RACT guidelines.

One of the two other affected facilities was assumed to require catalytic incineration with heat recovery to meet RACT requirements, while the other facility can implement waterborne coating (assumes that a suitable waterborne coating is developed to meet the specifications of the wire industry sector it serves). Based on these assumptions, capital requirements are estimated at $1.5 million and annualized costs at $240,000 (1 percent to 2 percent of the statewide industry value of shipments).

No significant productivity, employment or market structure dislocations will be associated with the implementation of the RACT guidelines.

Incinerator equipment manufacturers believe they can meet the anticipated demand for high heat recovery incinerators designed specifically for magnet wire ovens.

1.3.6 Surface Coating of Large Appliances

There are 12 companies identified as coaters of large appliances in Michigan. The industry statewide would be required to invest approximately $4.8 million in capital and incur additional annualized costs of $1.1 million (approximately 0.08 percent of industry statewide value of shipments).

Assuming a "direct cost pass-through," the cost increase for household appliances relates to a price increase of $0.20 per unit. Certain manufacturers could incur disproportionate compliance costs, which could further deteriorate the profit position of marginally profitable operations. Of the firms with marginally profitable operations that may be severely affected, none of the companies contacted indicated that they might be forced out of business. No major productivity, employment or market structure dislocations appear to be associated with implementation of the RACT guidelines.

The high solids (greater than 62 percent by volume) topcoat application technique preferred by the industry has not been proven under normal operating conditions although it appears to be technically feasible.

1.3.7 Solvent Metal Cleaning

This category includes equipment to clean the surface for removing oil, dirt, grease and other foreign material by immersing the article in a vaporized or liquid organic solvent. The cleaning is done in one of three devices: a cold cleaner, an open top vapor degreaser, or a conveyorized degreaser. This type of cleaning is done by many firms in many different types of industries.

Implementation of the proposed RACT guidelines for an estimated 15,000 cleaning operations is expected to have a negligible economic effect on industry because of the relatively minor changes required. Statewide, the many facilities potentially affected represent a capital cost of $5.9 million and an annualized cost of $700,000 (approximately 0.0012 percent of industry value of shipments).

Because of the large number of degreasers (approximately 15,000) that require retrofit to meet RACT and the inability of manufacturers to provide equipment on such a large scale, it is doubtful if all degreasers can be retrofitted nationwide within the 1982 timeframe.

No major productivity, employment and market structure dislocations will result from RACT implementation.

1.3.8 Bulk Gasoline Plants

This industry is characterized by many small plants. Of these plants, only a few percent are either new or modernized. The majority of the plants are over 20 years old. Most bulk plants are located in rural areas where implementation of RACT to stationary sources may not be required. However, the economic analysis presented includes all bulk gas plant facilities, regardless of location.

To meet the RACT requirements, bulk gas plants must be equipped with vapor balance and submerged fill systems. This recommended control system is not cost-effective for the bulk plant operator as most of the economic credit (for recovered vapors) would be accrued to a bulk terminal or refinery.

The estimated capital cost and annualized cost to meet compliance requirements represent $12.4 million and $3.3 million (approximately 0.6 percent of industry statewide value of shipments), respectively. The compliance costs may create market price increase. Industrywide, the price of gasoline (assuming a "direct cost pass-through) would be increased $0.0025 per gallon, but the small volume operators would be more severely affected, with costs increasing between $0.005 per gallon and $0.01 per gallon. Because of the competitiveness and low profit structure in the industry, further cost increases could force the marginal operations out of the business, thus further concentrating the market structure. In urban areas, the bulk gasoline plant markets have been declining because of competition from retailers and tank truck terminals, and are expected to continue to decline regardless of the RACT guidelines.

The implementation of the RACT alternatives of bottom filling and vapor balancing could produce an energy saving equivalent to 78,000 barrels of oil per year assuming a control efficiency as defined by the RACT guidelines. This assumed control efficiency has not been effectively demonstrated.

1.3.9 Storage of Petroleum Liquids in Fixed Roof Tanks

There are approximately 160 fixed roof tanks, each of which is greater than 40,000 gallons and used for storing petroleum liquids.

These tanks are owned by major oil companies, large petrochemical firms and bulk gasoline tank terminal companies. The capital cost to equip these fixed roof tanks with a single floating roof is estimated to be $20 million. The estimated annualized cost is $3.1 million, which would represent a price increase (assuming "direct cost pass-through") of less than $0.001 per gallon of throughput.

One problem may be the availability of equipment to implement the RACT standard within the timeframe of the guidelines.

No significant productivity, employment or market structure dislocations will be associated with the implementation of the RACT guidelines.

Implementation of the RACT guideline is estimated to represent a net energy savings of 140,000 equivalent barrels of oil annually (assuming 90 percent control efficiency.)

1.3.10 Service Stations

Of the estimated 13,570 potentially affected gasoline dispensing facilities located in Michigan, 5 percent are considered small gasoline stations (throughput less than 10,000 gallons per month). These stations will experience a cost increase of nearly $0.0025 per gallon to implement RACT; larger stations will experience a much smaller unit cost increase. Statewide, the industry capital cost is $12.9 million and annualized cost is $3 million (approximately 0.12 percent of the statewide value of gasoline sold for implementing submerged fill and vapor balancing. The service stations could experience loss of business while vapor control systems are being installed.

Implementation of the RACT guidelines may accelerate the trend to high throughput stations because of the increasing overhead costs. However, the RACT guidelines will not cause major productivity and employment dislocations to the industry as a whole.

It is estimated that implementing RACT guidelines for service stations in Michigan will result in a net energy savings equivalent to approximately 122,000 barrels of oil per year, assuming 98 percent recovery of gasoline. This assumed control efficiency has not been fully proven. The economic benefit of the recovered gasoline vapors will not directly accrue to the service stations.

* * * *

A summary of the direct economic implications of implementing RACT in each of the 10 industrial categories studied is presented in Exhibits 1-4 through 1-13, on the following pages.

EXHIBIT 1-4 (1)

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR CAN MANUFACTURING PLANTS IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	There are five can manufacturing facilities
Indication of relative importance of industrial section to state economy	1977 value of shipments was $110 million. Industry is closely related to state's food, dairy and beverage industries
Current industry technology trends	Beer and beverage containers rapidly changing to two-piece construction
1977 VOC emissions (actual)	900 tons per year (the industry reportedly has no emission controls in place in 1977)
Industry preferred method of VOC control to meet RACT guidelines	Low solvent coatings (waterborne)
Assumed method of control to meet RACT guidelines	75 percent of cans coated with low solvent coatings; 25 percent of coated cans requiring incinerator for control

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$430,000 (approximately 10 percent of current annual capital appropriations for the industry)
Annualized cost (statewide)	$160,000 (approximately 0.14 percent of the industry's 1977 statewide value of shipments)
Price	Assuming a "direct cost pass through" less than $0.002 can increase (based on a can value of $0.085 per can)
Energy	Increase of 3,250 equivalent barrels of oil annually for operation of facilities that have to utilize incinerators
Productivity	No major impact
Employment	No major impact

EXHIBIT 1-4. (2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
Market structure	Accelerated technology conversion to two-piece cans, further concentration of sheet coating operations into larger facilities
RACT timing requirements (1982)	Low solvent coating volume requirements and FDA approval may require some facilities to meet the RACT requirements with incineration (rather than low solvent coating technology)
Problem area	Low solvent coating technology for end sealing compound
VOC emission after RACT control	200 tons per year (21 percent of 1977 emission level)
Cost effectiveness of RACT control	$225 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-5
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR COIL COATING FACILITIES IN
THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	There are four coil coating facilities potentially affected by the coil coating RACT guideline in Michigan. Three firms currently meet RACT emission limitations.
Current industry technology trends	Due to the pressures of energy availability as well as environmental protection, most firms have or are installing regenerative-type incinerators
1977 VOC emissions (actual)	400 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Regenerative thermal incineration
Assumed method of control to most RACT guidelines	Regenerative thermal incineration

Affected Areas in Meeting RACT	Discussion
Capital Investment (statewide)	$250,000 incremental capital required by one firm if they were to install controls on a new processing line
Annualized Cost (statewide)	$75,000 (approximately 0.3 percent of industry's 1977 statewide value of shipments)
Energy	Small increased fuel consumption for regenerative incineration
Productivity	No major impact
Employment	No major impact
Market structure	The captive coil coating operation not meeting the RACT limitation may opt to purchase coated material in lieu of investing significant capital requirements
RACT timing requirements (1982)	Since most coil coating facilities in Michigan meet the RACT limitations, timing requirements should be met
Problem area	Low solvent coating technology is currently inadequate to meet product requirements
VOC emission after control	150 tons per year (37 percent of 1977 VOC emission level)
Cost effectiveness of control	$300 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-6 (1)

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR PAPER COATERS IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	Approximately 30 plants have been identified from the emission inventory. About 17 of these would be affected by the regulations. However, if this category is interpreted to include all types of paper coating, including publishing far more firms would be affected.
Indication of relative importance of	The 1977 value of shipments of the 30 plants identified is estimated to be approximately $300 million. These plants employment is estimated to be approximately 3,500
Current industry technology trends	Gravure coating replacing older systems
1977 VOC emissions (actual)	Approximately 13,000 tons per year were identified from the emission inventory. Actual emissions are expected to be higher.
Industry preferred method of VOC control to meet RACT guidelines	Though low solvent coating use is increasing, progress is slow. Add-on control systems will probably be used.
Assumed method of control to meet RACT guidelines	Thermal incineration with primary and secondary heat recovery

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	Estimated to be $13 million to $16 million depending on retrofit situations. This is likely to represent greater than 100 percent of normal expenditures for the affected paper coaters.
Annualized cost (statewide)	$3.2 million to $4.7 million annually. This represents approximately 1.0 to 1.5 percent of the 1977 annual sales for the affected paper coaters.
Price	Assuming a "direct cost pass-through"--1.0 to 1.5 percent
Energy	Assuming 35 percent heat recovery annual energy requirements are expected to increase by approximately 55,000 equivalent barrels of oil annually.
Productivity	No major impact
Employment	No major impact
Market structure	Smaller firms may be unable to secure capital funding for add-on systems, which are typically $250,000 or more for a moderate sized incinerator to over $1 million for a carbon adsorber.
RACT timing requirements (1982)	RACT guideline needs clear definition for rule making. Equipment deliverables and installation of incineration systems prior to 1982 are expected to present problems
Problem areas	Retrofit situations and installation costs are highly variable Type and cost of control depend on particular solvent systems used and reduction in air flow

EXHIBIT 1-6 (2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
VOC emissions after RACT control	2,500 tons/year (20 percent of 1977 VOC emission level)
Cost effectiveness of RACT control	$300 - $450 annualized cost/annual ton of VOC reduction

Note: Cost data is based on emission information supplied by the Michigan Department of Natural Resources

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-7
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR FABRIC COATERS IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	Three firms were identified as being affected by the proposed regulation
Indication of relative importance of industrial section to state economy	Total value of shipments by the three plants identified is about $100 million. These plants employ about 1,600 persons
Current industry technology trends	Newer plants are built with integrated coating and emission control systems; older plants such as those expected to be affected in Michigan, are only marginally competitive now
1977 VOC emissions (actual)	Current emissions are estimated at about 3,000 tons/year
Industry preferred method of VOC control to meet RACT guidelines	Direct fired incineration for short range, low solvent coatings are a long range goal
Assumed method of VOC control to meet RACT guidelines	Direct fired incineration with primary and secondary heat recovery

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	Study team estimate is about $4.8-6.4 million. Companies affected estimate costs to be as much as $10 million
Annualized cost (statewide)	Approximately $1.3 million to $1.7 million which represents 1 percent of the industry's 1977 statewide value of shipments
Price	Assuming a "direct pass-through of costs" prices of coated fabrics will increase by about 1 percent
Energy	Assuming 70 percent heat recovery about 14,000 equivalent barrels of additional fuel oil would be required per year
Productivity	No major impact
Employment	No major impact
Market Structure	No change in market structure within the state is anticipated; firms affected have different product lines
RACT timing requirements (1982)	Plants may have problem in control equipment deliveries
Problem areas	Additional capital and operating costs may make the plants uncompetitive with more modern and efficient ones Capital and operating costs can only be approximated because of unknown retrofit situations
VOC emissions after RACT control	450 tons/year (19 percent of 1977 VOC emissions) RACT will account for a total of about 1,900 tons/year reduction
Cost effectiveness of RACT control	$650 annualized cost/annual ton of VOC reduction

Note: Cost data is based on emission information supplied by the Michigan Department of Natural Resources.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-8

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURFACE COATING FOR INSULATION OF MAGNET WIRE IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	There are four facilities that coat magnet wire, of which two do not meet the RACT emission limitations
Indication of relative importance of industrial section to state economy	1977 statewide value of shipments was estimated at $16 million and represents 2 percent of the estimated $830 million value of shipments of the magnet wire industry nationwide
1977 VOC emissions (actual)	465 tons per year, of which 277 are subject to control
Industry preferred method of VOC control to meet RACT guidelines	Waterborne coating or add-on catalytic incinerator with primary heat recovery
Assumed method of VOC control to meet RACT guidelines	Waterborne coatings (where applicable) or add on catalytic incinerator with primary heat recovery

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$1.5 million (estimated to be over 100 percent of current annual capital approximations of the affected facilities)
Annualized cost (statewide)	$240,000 which represents 1.5 percent of the industry's 1977 statewide value of shipments
Price	Increase of an average of $0.02 per pound of wire coated (based on a price of $1.20 per pound)
Energy	Reduced natural gas requirements due to primary heat recovery (equivalent to 10,000 barrels of oil per year)
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
RACT timing requirements (1982)	No problems meeting equipment deliveries and installation are anticipated
Problem area	Commercial application of waterborne coating has not been completely developed Large capital requirements will cause severe capital drain on the affected facilities
VOC emissions after RACT control	35 tons/year (13 percent of 1977 VOC emission level subject to control)
Cost effectiveness of RACT control	$1,000 annualized cost/ton VOC reduction

---

Note: Cost data are based on emission information supplied by the Michigan Department of Natural Resources

Source: Booz, Allen & Hamilton Inc.

EXHIBIT I-9

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	There are twelve major large appliance manufacturers and coaters
Indication of relative importance of industrial section to state economy	1977 statewide value of shipments was estimated at $1.4 billion and represents 9 percent of the estimated $15 billion U.S. value of shipments of the major appliance industry
1977 VOC emissions (actual)	1,000 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Waterborne primecoat and high solids topcoat
Estimated method of VOC control to meet RACT guidelines	Waterborne primecoat and high solids topcoat

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$4.8 million
Annualized cost (statewide)	$1.1 million which represents 0.08 percent of the industry's 1977 statewide value of shipments.
Price	Assuming a "direct cost pass-through"--increase of $0.20/unit for household appliances (based on a price of $193 per unit appliance)
Energy	Reduced natural gas requirements in the curing operation (equivalent to 2,400 barrels of oil per year)
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
RACT timing requirements (1982)	Possible problem meeting equipment deliveries and installation are anticipated if majority of firms require deliveries in the same time frame
Problem area	Commercial application of high solids (greater than 62% by volume) has not been proven
VOC emission after RACT control	300 tons/year (30 percent of 1977 emission level)
Cost effectiveness of RACT control	$1,576 annualized cost/ton VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-10

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	15,000-20,000 plants
Indication of relative importance of industrial section to state economy	Value of shipments of firms in SIC groups affected is in the range of $58 billion, about two-thirds of the state's 1977 value of shipments.
Current industry technology trends	Where technically feasible, firms are substituting exempt solvents
1977 VOC emissions (actual)	42,500 Tons/year of which 17,500 tons are subject to RACT
Industry preferred method of VOC control to meet RACT guidelines	Substitution. Otherwise lowest cost option as specified by EPA will be used.
Assumed method of VOC control meet RACT guidelines	Equipment modifications as specified by the RACT guidelines

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$5.9 million
Annualized operating cost (statewide)	$0.7 million, (approximately 0.0012 percent of the 1977 statewide value of shipments)
Price	Metal cleaning is only a fraction of manufacturing costs; price affect expected to be less than 0.0012 percent
Energy	Less than a 1000 equivalent barrels of oil per year in reduction
Productivity	5-10 percent decrease for manually operated degreasers. Will propably not affect conveyorized cleaners.
Employment	No effect except a possible slight decrease in firms supplying metal degreasing solvents
Market Structure	No change
RACT timing requirements (1982)	Equipment availability--only a few companies now supply the recommended control modifications
Problem Areas	No significant problem areas seen. Most firms will be able to absorb cost.
VOC emission after RACT control	32,500 tons/year (76 percent of 1977 VOC emission level--however, this does not include emission controls for exempt solvents)
Cost effectiveness of RACT control	$70 annualized cost per ton of emissions reduced

Source: Booz, Allen & Hamilton Inc.

Exhibit 1-11

U.S. Environmetnal Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR BULK GASOLINE PLANTS IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	800
Indication of relative importance of industrial section to state economy	1977 industry sales were $520 million. The estimated annual throughput was 1.22 billion gallons. Primary market is rural accounts
Current industry technology trends	Only small percent of industry has new/modernized plants
1977 VOC actual emissions	15,400 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Top submerged or bottom fill and vapor balancing (cost analysis reflects top submerged fill, not bottom fill)

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$12.40 million
Annualized cost (statewide)	$3.3 million (approximately 0.6 percent of value of shipments)
Price	Assuming a "direct cost pass-through" . Industry-wide—$0.0025 per gallon increase . Small operations--$0.0025 to $0.005 per gallon increase
Energy	Assuming full recovery of gasoline—net savings of 77,875 equivalent barrels annually
Productivity	No major impact
Employment	No major impact; however, for plants closing, potential average of 4.6 jobs lost per plant closed
Market structure	Regulation could further concentrate a declining industry. Many small bulk plants today are marginal operations; further cost increases could result in some plant closings
Problem areas	**Potential economic impact for small bulk plant operations. Regulation could cause further market imbalances. Control efficiency of cost effective alternative has not been effectively demonstrated**
VOC emission after control	4,000 tons per year
Cost effectiveness of control	$289 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

Exhibit 1-12

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR STORAGE OF PETROLEUM LIQUIDS IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected storage tanks	160
Indication of relative importance of industrial section to state economy	The annual throughput was an estimated 5.5 billion gallons
Current industry technology trends	Internal floating roof tanks utilizing a double seal have been proven to be more cost effective
1977 VOC emissions (actual)	20,400 tons per year
Preferred method of VOC cotrol to meet RACT guidelines	Single seal and internal floating roof

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$20 million
Annualized cost (statewide)	$3.1 million
Price	Assuming a "direct cost pass-through"—less than $0.001 per gallon of throughput
Energy	Assuming 90 percent reduction of current VOC level, the net energy savings represent an estimated savings of 140,000 equivalent barrels of oil annually
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
Problem area	Potential availability of equipment to implement RACT standard
VOC emission after RACT control	2,000 tons per year
Cost effectiveness of RACT control	$170 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

Exhibit 1-13

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR GASOLINE SERVICE STATIONS IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	Approximately 13,570 of the estimated 17,185 gasoline dispensing facilities in the state are potentially affected
Indication of relative importance of industrial section to state economy	Industry sales are $2.48 billion with a yearly throughput of 4.88 billion gallons
Current industry technology trends	Number of stations has been declining and throughput per station has been increasing. By 1980, one-half of stations in U.S. will be totally self-service
1977 VOC actual emissions	45,000 tons per year from tank loading operation
Industry preferred method of VOC control to meet RACE guidelines	Submerged fill and vapor balance

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$12.9 million
Annualized cost (statewide)	$3.0 million (approximately 0.12 percent of the value of gasoline sold statewide)
Price	Assuming a "direct cost pass-through"--less than $.0008 per gallon increase
Energy	Assuming full recovery of gasoline--net savings of 122,000 equivalent barrels of oil annually
Productivity	No major impact
Employment	No major impact
Market structure	Compliance requirements may accelerate the industry trend towards high throughput stations
Problem area	Older stations face higher retrofit costs--potential concerns are dislocations during installation
VOC emissions after control	27,156 tons per year from tank loading operation
Cost effectiveness of control	$170 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

2.0 INTRODUCTION AND OVERALL STUDY APPROACH

2.0 INTRODUCTION AND OVERALL STUDY APPROACH

This chapter presents an overview of the study's purpose, scope, methodology and quality of estimates. This chapter is divided into six sections:

- Background
- Purpose of the contract effort
- Scope
- Approach
- Quality of estimates
- Definitions of terms used.

The approach and quality of the estimates are discussed in detail in the respective chapters dealing with the specific RACT industrial categories (Chapters 3 through 17).

2.1 BACKGROUND

To reduce volatile organic compound (VOC) emissions from stationary sources, the U.S. Environmental Protection Agency (EPA) is developing a series of conceptual regulations based on technology limitations. These regulations are meant to guide the states in revising their State Implementation Plan (SIP) to achieve the mandated National Amendment Air Quality Standards for oxidants. The Clean Air Act Amendments of 1977 require that each state have SIP revisions approved by EPA by January 1, 1979.

Specifically, the EPA requires that the oxidant plan submissions for major urban areas should contain regulations to reflect the application of Reasonably Available Control Technology (RACT) to stationary sources for which the EPA has published guidelines. Recommended VOC limitations representative of RACT have been prepared for the following industrial categories.

- Control Of Volatile Organic Emissions From Existing Stationary Sources--Surface Coating Of:
    - Cans
    - Coils
    - Paper
    - Fabrics
    - Automobiles
    - Light-Duty Trucks
    - Metal Furniture
    - Insulation Of Magnet Wire
    - Large Appliances
- Control Of Volatile Organic Emissions From Solvent Metal Cleaning
- Control Of Refinery Vacuum Producing Systems, Wastewater Separators And Process Unit Turnarounds
- Gasoline Marketing--Control Of:
    - Tank Truck Gasoline Loading Terminals
    - Volatile Organic Emissions From Bulk Gasoline Plants
    - Volatile Organic Emissions From Storage Of Petroleum Liquids In Fixed-Roof Tanks
    - Service Stations--Stage I
- Control Of Volatile Organic Compounds From Use Of Cutback Asphalt.

Under the direction of Region V, the EPA commissioned Booz, Allen and Hamilton Inc. (Booz, Allen) to determine the economic impact of implementing RACT standards in four states:

- Illinois
- Michigan
- Ohio
- Wisconsin.

The assignment was initiated on June 1, 1978, and the research stage of the project was completed over a three-month to four-month period, depending on the individual state requirements. A report was issued for each of the four states being studied.

2.2 PURPOSE OF THE CONTRACT EFFORT

To determine the economic impact of implementing RACT standards for industrial categories in four states (Illinois, Michigan, Ohio and Wisconsin) of Region V of the U.S. Environmental Protection Agency. These studies will be used primarily to defend EPA and state decisions on achieving the emission limitations of the RACT standards.

2.3 SCOPE

The primary task of this project is to determine the costs and impact of control to achieve RACT guideline limitations. The impact must be addressed for each industry and for each state so that the respective studies are applicable to individual state regulations. Direct economic costs and benefits that can be realized from RACT implementation shall be identified and quantified. While secondary (social, energy and employment) impacts are to be addressed, they are not to be the major emphasis in the study. In summary, an economic impact will be analyzed for each of the industry categories in each state and the economic impact of the RACT guidelines will be aggregated statewide.

In Michigan, the economic impact is assessed for the following 10 RACT industrial categories:

- Surface coating of cans
- Surface coating of coils
- Surface coating of paper
- Surface coating of fabrics
- Surface coating for insulation of magnet wire
- Surface coating of large appliances
- Solvent metal cleaning
- Bulk gasoline plants
- Storage of petroleum liquids in fixed roof tanks
- Service Stations--Stage I.

Five other RACT industrial categories, that were studied for the states of Illinois, Ohio and Wisconsin, were not assessed for Michigan. The primary reason for this exclusion of categories was that state representatives felt that detailed knowledge and resources were available to perform the economic impact assessment. The RACT industrial categories excluded for Michigan are:

- Surface coating of automobiles and light duty trucks
- Surface coating of metal furniture
- Bulk gasoline terminals
- Refinery vacuum producing systems, wastewater separators and process unit turnarounds
- Use of cutback asphalt.

In the determination of the economic impact of the RACT guidelines, the following are the major study guidelines:

- The emission limitations for each industrial category were studied at the control level established by the RACT guidelines. These are presented in Exhibit 2-1, on the following page.

EXHIBIT 2-1 (1)
U.S. Environmental Protection Agency
LISTING OF EMISSION LIMITATIONS THAT REPRESENT
THE PRESUMPTIVE NORM TO BE ACHIEVED THROUGH
APPLICATION OF RACT FOR TEN INDUSTRY CATEGORIES

Category	RACT Guideline Emission Limitations[a] Surface Coating Categories Based on Low Organic Solvent Coatings (lbs. solvent per gallon of coating, minus water)
Surface Coating Of:	
Cans	2.8
. Sheet basecoat (exterior and interior) Overvarnish Two-piece can exterior (basecoat and overvarnish)	
. Two and three-piece can interior body spray Two-piece can exterior end (spray or rollcoat)	4.2
. Three-piece can side-seam spray	5.5
. End sealing compound	3.7
Coils	
. Prime and topcoat or single coat	2.6
Paper	2.9
Fabrics and vinyl coating	
. Fabric	2.9
. Vinyl	3.8
Magnet Wire	1.7
Large appliance	
. Prime, single or topcoat	2.8
Solvent Metal Cleaning	
. Cold cleaning	Provide cleaners with: cover; facility to drain clean parts; additional freeboard; chiller or carbon absorber. Follow suggested procedures to minimize carryout
. Conveyorized degreaser	Provide cleaners with: refrigerated chillers; or carbon adsorption system; drying tunnel or rotating basket; safety switches, covers. Follow suggested procedures to minimize carryout
. Open top degreaser	Provide cleaner with: safety switches; powered cover; chiller; carbon absorber. Follow suggested procedures to minimize carryout
Bulk Gasoline Plants	Provide submerges filling and vapor balancing so that VOC emissions from control equipment do not exceed 80 milligrams per liter (4.7 grains per gallon) of gasoline loaded

EXHIBIT 2-1 (2)
U.S. Environmental Protection Agency

Category	RACT Guidelines Emission Limitations[a]
Storage of Petroleum Liquids in Fixed Roof Tanks	Provide single seal and internal floating roof to all fixed roof storage vessels with capacities greater than 150,000 liters (39,000 gal.) containing volatile petroleum liquids for which true vapor pressure is greater than 10.5 kilo Pascals (1.52 psia)
Service Stations (Stage I)	Provide submerged fill and vapor balance for any stationary storage tank located at a gasoline dispensing facility

---

[a] Annotated description of RACT guidelines

Source: Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, U.S. Environmental Protection Agency, EPA-905/2-78-001, April 1978.

- The timing requirement for implementation of controls to meet RACT emission limitations was January 1, 1982.
- All costs and emission data were presented for 1977.
- Emissions sources included were existing stationary point sources in the applicable industrial categories with VOC emissions greater than 3 pounds in any hour or 15 pounds in any day.
- The impact of each of the RACT guidelines was studied statewide (i.e., attainment areas, nonclassified areas and other areas that might not be regulated to the guidelines stated above are included in this analysis).
- The following volatile organic compounds were exempted:
  - Methane
  - Ethane
  - Trichlorotriblorethane (Freon 113)
  - 1,1,1-trichloroethane (methyl chloroform).[1]
- The cost of compliance was determined from the current level of control (i.e., if an affected facility currently had an incinerator in place, the cost of compliance and resulting VOC emission reduction are not included in this analysis).

---

[1] The exemption status of methyl chloroform under these guidelines may be subject to change.

2.4 APPROACH

This section describes the overall approach and methodology applied in this assignment. In general, the approach varied for each state and also for each industrial category studied. This section specifically describes the overall approach that was applied for the state of Michigan. The methodology applied to determine the economic impact for each of the ten RACT industrial categories in Michigan is described in further detail in the first section of each chapter dealing with the specific RACT category.

There are four parts to this section to describe the approach for determining estimates of:

- Industry statistics
- VOC emissions
- Process descriptions
- Cost of controlling VOC emissions.

2.4.1 Industry Statistics

The assembly of economic and statistical data for each industrial category was an important element in establishing the data base that was used for projection and evaluation of the emissions impact. Some of the major variables for each industrial category were:

- Number of manufacturers
- Number of employees
- Value of shipments
- Number of units manufactured
- Capital expenditures
- Energy consumption
- Productivity indices
- Current economics (financial) status
- Industry concentration
- Business patterns (small vs. large; downstream integration)
- Age distribution of facilities
- Future trends and developments.

Some of the industrial categories studied cover a large number of potentially affected facilities. For these categories, industry statistical data were collected by applying a categorical approach rather than by attempting to identify all the individual firms likely to be affected. The industrial categories studied by this approach included:

- Solvent metal cleaning
- Bulk gasoline plants
- Storage of petroleum liquids in fixed roof tanks.

For these industrial categories, secondary data sources and nonconfidential Booz, Allen files served as the primary resources for the data base. Industry and association interviews were then conducted to complete, refine and validate the industry statistical data base.

For the six surface coating RACT industry categories studied (cans, paper, fabrics, magnet wire, large appliances and coils) the number of facilities potentially affected was in a manageable range (generally less than 30 facilities per RACT industrial category); therefore, a more deliberate approach was applied:

- As a first step, the facilities potentially affected by the RACT guidelines were identified from both the Michigan emission inventory and secondary data sources.
    - These two independently compiled lists were then corrolated to identify the facilities potentially affected but not listed as VOC emitters in the Michigan emission inventory.
    - The Booz, Allen study team then performed telephone interviews with a sampling of the facilities identified where there was doubt concerning inclusion. (For industrial categories where only a few facilities were identified, such as coil coating, all the potentially affected facilities were contacted.)
- Industry category statistical data were compiled using secondary sources such as:
    - Department of Commerce
    - Census of Manufactures
    - Trade associations
    - Bureau of Labor Statistics
    - National Technical Information Services.
- The industry statistical data were refined by two mechanisms:
    - Assessing the statistical data for reasonableness in comparison to the list of potentially affected facilities
    - Using industry and association interviews for completion and validation.

2.4.2 VOC Emissions

An approach that made maximum utilization of the existing Michigan emission inventory was defined.

- State EPA representatives were interviewed to determine the completeness and validity of emission data available for each RACT industrial category. It was determined that:
  - VOC emission data for major industrial sources appeared to be reasonable.
  - The emission inventory provided relevant data that could be utilized for economic evaluation, i.e., air flow rate, type of process, the input and emission factors.
  - The data base was not compiled in a baseline consistent with the RACT industrial categories.
- A project task was established to compile data from the Michigan emission inventory for relevant industrial categories. These RACT industrial categories included:
  - Cans
  - Coils
  - Fabrics
  - Paper
  - Magnet wire
  - Large appliances
  - Fixed roof tanks.
- For the other RACT categories to be studied, the emissions were estimated by applying relevant factors (VOC emissions per facility, thruput, etc.) that had been developed by EPA studies. Although this categorical approach cannot be validated to the degree of a point source by point source approach, the emissions can be reasonably estimated on a statewide basis because of the large number of sources in each RACT industrial category. Emissions were estimated by this approach for the following RACT industrial categories:
  - Bulk gasoline plants
  - Solvent metal cleaning
  - Service stations.

- The emission estimates for each of the ten RACT industrial categories studied were refined during industry interviews.

2.4.3 Process Descriptions

For each of the industrial categories, the basic technology and emission data were reviewed and summarized concisely for subsequent evaluation of engineering alternatives. In this task, the RACT documents that had been prepared for each industrial category and other air pollution control engineering studies served as the basis for defining technological practice. Additional alternatives to control that met the requirements of the RACT guidelines were identified from literature search. The most likely control alternatives were assessed and evaluated by:

- Technical staff at Booz, Allen
- Interviews with industry representatives
- Interviews with EPA representatives
- Interviews with equipment manufacturers.

2.4.4 Cost of Controlling VOC Emissions

The cost of control to meet the requirements of the RACT guidelines had been presented in the RACT documents, other technical EPA studies and trade journal technical documents and by industry representatives. The approach applied in developing capital and annualized cost estimates was to:

- Utilize available secondary source information as the primary data source.

- Validate the control alternatives industry is likely to apply.

- Calibrate these cost estimates provided in technical documents.

It was not within the purpose or the scope of this project to provide detailed engineering analyses to estimate the cost of compliance.

Cost data presented within the body of the report were standardized in the following manner:

- All cost figures are presented for a base year, 1977.

- Capital cost figures represent installed equipment cost including:

  - Engineering
  - Design
  - Materials
  - Equipment
  - Construction.

  The capital cost estimates do not account for costs such as:

  - Clean-up of equipment
  - Lost sales during equipment downtime
  - Equipment startup and testing
  - Initial provisions (spare parts).

- Capital related annual costs are estimated at 25 percent of the total capital cost per year (unless explicitly stated otherwise). The estimation procedure applied was built up from the following factors:

  - Capital recovery factor for interest and depreciation of 16.3 percent, based on a 10 percent interest rate and 10 year life of equipment.[1]

---

[1] Depreciation and interest charges are based on a formula supplied by EPA for an equal payment series capital recovery factor:

$$A = P \left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$

where:

A = annualized charge for depreciation and interest

P = initial amount invested

i = annual interest rate

n = life of investment in years

For the current study, the interest rate (i) is assumed to be 10 percent, based on guidance provided by EPA. Investment life (n) is assumed to be 10 years. This is based on figures used in other studies, generally ranging from 10 to 12 years. The lower figure was selected as most applicable because, with retrofit situations, the useful life of the equipment is affected both by its own life and by the remaining life of the system to which it is added. When major modifications would be required to a processing line (such as automobile assembly plants) that would affect the useful life of the facility, a lower investment life should be applied.

- Maintenance--4 to 5 percent

- Taxes and insurance--4 percent.

The capital-related annual costs do not account for investment costs in terms of return on investment parameters (i.e., the "opportunity cost" of money is not included).

- Annual operating costs of compliance with the RACT guidelines were estimated for each of the control alternatives studied. The annual operating costs included were:

  - Direct labor
  - Raw material costs (or savings)
  - Energy
  - Product recovery cost (or savings).

  Other types of costs, not included in this analysis, involve compliance costs, such as:

  - Demonstration of control equipment efficiency

  - Supervisory or management time

  - Cost of labor or downtime during installation and startup.

- The annualized cost is the summation of the annual operating costs and the capital related annual costs.

2.4.5 Comparison of Direct Cost with Selected Direct Economic Indicators

In each of the industrial categories studied, after the costs (or savings) of compliance had been determined, these costs were compared with selected economic indicators. This comparison was performed to gain a perspective on the compliance costs rather than to estimate price changes or other secondary effects of the regulation. Presented below are typical comparisons of direct costs with indicators that are presented in this study.

- Annualized cost in relation to current price--To gain a perspective on the compliance cost in relation to current prices of the manufactured items at the potentially affected facilities, the annualized cost is presented in terms of a price increase assuming a direct pass-through of costs to the marketplace.

- This analysis was based on the average cost change (including those facilities that may have little or no economic impact associated with meeting the proposed standards) divided by the average unit price of goods manufactured.

- For this reason as well as many others (that might be addressed in a rigorous input-output study to estimate eventual price increase), this analysis should not be interpreted as a forecast of price changes due to the proposed standards.

- Annualized costs as a percent of current value of shipment--The annualized costs applied are for all those facilities potentially affected divided by the estimated value of shipments for the statewide industrial category (i.e., including those facilities which currently may meet the proposed standard). This approach tends to understate the effect to those specific firms requiring additional expenses to meet the proposed standard. Therefore, when available, the compliance cost is also presented as a percent of the value of shipments for only those firms not currently meeting the proposed regulation.

- Capital investment as a percent of current annual capital appropriations--Estimated statewide capital investment for the potentially affected facilities divided by the estimated capital appropriations for the industry affected as a whole in the state (including those facilities that may not require any capital investment to meet the proposed standard).

2.5 QUALITY OF ESTIMATES

The quality of the estimates that are presented in this report can be judged by evaluating the basis for estimates of the individual study components. In each of the chapters that deal with the development of estimated compliance cost, the sources of information are fully documented. In addition, the study team has categorically ranked the overall data quality of the major sources and, therefore, of the outcomes. These data quality estimates were ranked into three categories:

- High quality ("hard data")--study inputs with variation of not more than ± 25 percent

- Medium quality ("extrapolated data")--study inputs with variation of ± 25 to ± 75 percent

- Low quality ("rough data")--study inputs with variation of ± 50 to ± 150 percent.

Each of these data quality estimates are presented in the individual chapters. The overall quality ranking of the study inputs for each RACT industrial category was generally in the medium quality range.

2.6 DEFINITIONS OF TERMS

Listed below are definitions of terms that are used in the body of the report:

- Capture system--the equipment (including hoods, ducts, fans, etc.) used to contain, capture, or transport a pollutant to a control device.
- Coating applicator--an apparatus used to apply a surface coating.
- Coating line--one or more apparatuses or operations which include a coating applicator, flash-off area and oven, wherein a surface coating is applied, dried and/or cured.
- Control device--equipment (incinerator, adsorber or the like) used to destroy or remove air pollutant(s) prior to discharge to the ambient air.
- Continuous vapor control system--a vapor control system that treats vapors displaced from tanks during filling on a demand basis without intermediate accumulation.
- Direct cost pass-through--the relationship of the direct annualized compliance cost (increase or decrease) to meet the RACT limitations in terms of units produced (costs per unit value of manufactured goods.)
- Emission--the release or discharge, whether directly or indirectly, of any air pollutant into the ambient air from any source.
- Facility--any building, structure, installation, activity or combination thereof which contains a stationary source of air contaminants.
- Flashoff area--the space between the application area and the oven.
- Hydrocarbon--any organic compound of carbon and hydrogen only.

- Incinerator--a combustion apparatus designed for high temperature operation in which solid, semisolid, liquid or gaseous combustible wastes are ignited and burned efficiently and from which the solid and gaseous residues contain little or no combustible material.

- Intermittent vapor control system--a vapor control system that employs an intermediate vapor holder to accumulate vapors displaced from tanks during filling. The control device treats the accumulated vapors only during automatically controlled cycles.

- Loading rack--an aggregation or combination of gasoline loading equipment arranged so that all loading outlets in the combination can be connected to a tank truck or trailer parked in a specified loading space.

- Organic material--a chemical compound of carbon excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate.

- Oven--a chamber within which heat is used to bake, cure, polymerize and/or dry a surface coating.

- Prime coat--the first film of coating applied in a two-coat operation.

- Reasonably available control technology (RACT)--the lowest emission limit as defined by EPA that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility. It may require technology that has been applied to similar, but not necessarily identical, source categories.

- Reid vapor pressure--the absolute vapor pressure of volatile crude oil and volatile nonviscous petroleum liquids, except liquified petroleum gases, as determined by American Society for Testing and Materials, Part 17, 1973, D-323-72 (Reapproved 1977).

- Shutdown--the cessation of operation of a facility or emission control equipment.

- Solvent--organic material which is liquid at standard conditions and which is used as a dissolver, viscosity reducer or cleaning agent.

- Standard conditions--a temperature of 20°C (68°F) and pressure of 760 millimeters of mercury (29.92 inches of mercury).

- Startup--the setting in operation of a source or emission control equipment.

- Stationary source--any article, machine, process equipment or other contrivance from which air pollutants emanate or are emitted, either directly or indirectly, from a fixed location.

- Topcoat--the final film of coating applied in a multiple coat operation.

- True vapor pressure--the equilibrium partial pressure exerted by a petroleum liquid as determined in accordance with methods described in American Petroleum Institute Bulletin 2517, "Evaporation Loss from Floating Roof Tanks," 1962.

- Equivalent barrel of oil--energy demand is converted into barrels of oil at the conversion rate of 6,000,000 BTU per barrel of oil.

- Vapor collection system--a vapor transport system which uses direct displacement by the liquid loaded to force vapors from the tank into a vapor control system.

- Vapor control system--a system that prevents release to the atmosphere of at least 90 percent by weight of organic compounds in the vapors displaced from a tank during the transfer of gasoline.

- Volatile organic compound (VOC)--any compound of carbon that has a vapor pressure greater than 0.1 millimeters of mercury at standard conditions excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates and ammonium carbonate.

3.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR CAN MANUFACTURING PLANTS IN THE STATE OF MICHIGAN

3.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR CAN MANUFACTURING PLANTS IN THE STATE OF MICHIGAN

This chapter presents a detailed economic analysis of implementing RACT controls for can manufacturing plants in the State of Michigan. The chapter is divided into five sections:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic implications.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of can manufacturing plants, interviews and analysis.

3.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for can manufacturing plants in Michigan.

The quality of the estimates is described in detail in the latter part of this section.

3.1.1 Industry Statistics

Industry statistics on can manufacturing plants were obtained from several sources. All data were converted to a base year 1977 based on specific scaling factors. The number of establishments for 1977 was based on the Michigan emission inventory and supplemented by a review of the 1976 County Business Patterns and interviews with selected can manufacturing corporations. The number of employees was obtained from the 1976 County Business Patterns and refined based on information supplied by the Can Manufacturers Institute.

The number of cans manufactured was based upon scaling up 1972 published data to 1977.

- The 1972 Census of Manufactures reported a total U.S. volume of shipments of 78 billion units with a value of $4.5 billion.

- The value of shipments in the East North Central Region was reported as:

State	Value of Shipments, 1972 ($ Million)	Percent of U.S. Total
Ohio	236.5	5.24
Illinois	465.9	10.33
Michigan	74.0	1.64
Wisconsin	Withheld	7.76
Indiana	Withheld	
TOTAL	1,126.5	24.97

- The value of shipments for 1976 in the U.S. was reported to be $6,357 million. Based upon the same ratio of state production to total U.S. production as in 1972, the 1976 production in the states was estimated to have been:

State	1976 Value of Shipments ($ Million)	Units Produced 1976 (Billion)
Ohio	333.3	4.4
Illinois	656.7	8.6
Michigan	104.3	1.4
Wisconsin	304.8	4.0

- For 1977, the U.S. Industrial Outlook, 1977, indicates that the increase in production is 3 percent, with a 10 percent increase in value of shipments. This factor was used to estimate 1977 can production and the value of shipments.
- The product mix of the type of cans currently produced in the state was estimated using the national average and refined using data obtained from the Michigan emissions inventory and from interviews.

3.1.2 VOC Emissions

The data for determining the current level of emissions from the three large plants were provided by the Michigan emission inventory. Emissions from the two other satellite assembly plants were estimated through the development of a representative can assembly plant. Most can manufacturing plants employ similar technology to produce the same product, so that there is a good correlation between can production and coating consumption once the type of can manufactured is known.

3.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions for can manufacturing plants are described in Control of Volatile Organic Emissions from Existing Stationary Sources, EPA-450/2-77-008. The data provide the alternatives available for controlling VOC emissions from can manufacturing plants. Several studies of VOC emission control were also analyzed in detail, and the industry trade association and can manufacturers were interviewed to ascertain the most likely types of control techniques to be used in can manufacturing plants in Michigan. The specific studies analyzed were Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories, and informational literature supplied by the Can Manufacturers Institute to the state EPA programs.

The alternative approaches to VOC control as presented in the RACT document were supplemented by several other approaches. The approaches were arrayed and the emissions to be reduced from using each type of control were determined. This scheme forms the basis of the cost analysis, for which the methodology is described in the following paragraphs.

3.1.4 Cost of Control Approaches and the Resulting Reduction in VOCs

The costs of VOC control approaches were developed by:

- Separating the manufacturing process into discrete coating operations:
  - By can manufacturing technology
  - By type of can manufactured; i.e., beer vs. food
- Determining the alternative approaches to control likely to be used for each type of coating operation
- Estimating installed capital costs for each approach
- Estimating the probable use of each approach to control considering:
  - Installed capital cost
  - Annualized operating cost
  - Incremental costs for materials and energy
  - Technical feasibility by 1981

  (This estimate was based on discussions with knowledgable individuals in the can manufacturing industry.)
- Aggregating costs to the total industry in Michigan.

Costs were determined from analysis of the previously mentioned studies:

- Control of Volatile Organic Emissions from Existing Stationary Sources, EPA-450/2-77-008
- Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories

and from informational data supplied by the Can Manufacturers Institute and from interviews with major can manufacturing companies.

The cost of compliance and the expected emission reduction in Michigan were developed based on plant operational data included in the Michigan emission inventory and refined during interviews with can manufacturers. Based upon the assessment of the degree and types of controls currently in place, the cost of VOC emission control and the net reduction in emissions were estimated.

3.1.5 Economic Impact

The economic impact was analyzed by considering the lead time requirements needed to implement RACT, assessing the feasibility of instituting RACT controls in terms of available technology, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary impacts on market structure, employment and productivity from implementing RACT controls in Michigan.

3.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on can manufacturing plants in Michigan. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data, "B" indicates data were extrapolated from hard data and "C" indicates data were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 3-1, on the following page, rates each study output and overall quality of the data. However, emission data are only as good as the assessment of the 1977 technical approach to emission controls, particularly the degree of usage of "exempt" solvents and the percentage of solvent that is actually incinerated.

EXHIBIT 3-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A "Hard Data"	B "Extrapolated Data"	C "Estimated Data"
Industry statistics	X	X	
Emissions		X	
Cost of emissions control			X
Statewide costs of emissions			X
Overall quality of data		X	

Source: Booz, Allen & Hamilton Inc.

3.2 INDUSTRY STATISTICS

Industry characteristics, statistics and business trends for can manufacturing plants in Michigan are presented in this section. The source of industry statistics was the Michigan emissions inventory, The Can Manufacturers Institute and the individual can manufacturing companies. Data in this section form the basis for assessing the impact of implementing RACT to VOC emissions from can manufacturing plants in the state.

3.2.1 Size of the Industry

The can manufacturing industry in Michigan is small when compared to the industry in other midwestern states. There are five or six can manufacturing facilities in the state; all relatively small by industry standards. These plants primarily assemble food and beverage cans from precoated stock shipped to the plants from facilities in other states. Exhibit 3-2, on the following page, presents a list of five can facilities in the state that have been identified. The sixth plant that was reported to the census data possibly was the American Can Company plant in Oak Park that was closed during 1976. The industry shipped 1.5 billion cans with an estimated value of $110 million in 1977, while employing 450 to 500 people. Can industry capital investments are estimated to have been $2 million to $8 million in 1977, based upon an extrapolation of 1972 data.

3.2.2 Comparison of the Industry to the State Economy

The Michigan can manufacturing industry employs 0.2 percent of the state labor force, excluding government employees. The state appears to be a net importer of cans, both in the form of coated stock and fabricated cans.

3.2.3 Characterization of the Industry

The can industry is composed of independent and captive manufacturers. Nationwide, about 70 percent of all cans are produced by independent manufacturers and about 30 percent by captive producers. The majority of captive can producers use the cans to package canned food/soup and beer. Of the five can manufacturing facilities identified in Michigan, two are independent and three are captive. There are no fully integrated can manufacturing plants in the state. All plants form cans from stock and ends coated in other states.

The independent can producers generally operate on a "job shop" basis, producing cans for several customers on the same production facilities. In addition to differences in can size and shape, there are differences in coatings resulting from:

EXHIBIT 3-2
U.S. Environmental Protection Agency
LIST OF METAL CAN MANUFACTURING FACILITIES
POTENTIALLY AFFECTED BY RACT IN MICHIGAN

Name Of Firm	Location	Product	Notes
Continental Can Company	Shoreham	3-piece food cans 3-piece soft drink cans	Can assembly only Predominantly food cans
Diversified Packages	Howell	3-piece beverage cans	Can assembly only Captive to Pepsi Cola Metro Bottling Co.
National Can Company	Livonia	3-piece beer and soft drink cans 3-piece food cans	Can assembly only
Ross Labs	Sturgess	3-piece infant formula cans	Can assembly only
H. J. Heinz	Holland	Not available	Not available

Source: Michigan emission inventory, Booz, Allen & Hamilton Inc.

- The need to protect different products with varying characteristics from deterioration through contact with the metal can

- The decoration requirements of customers and requirements for protection of the decoration.

Nationally, the can industry produces more than 600 different shapes, styles and sizes to package more than 2,500 products. A relatively few can sizes and coating combinations employed for packaging beverages and food represent about 80 percent of the market. The approximate percentage of total can production represented by the major groups follows:

Type of Can	Percent of Total Production
Beer and soft drink	54
Fruit and vegetable	18
Food cans in the category that includes soup cans	8
Other	20
TOTAL	100

In Michigan, the small can industry is focused on meeting the needs of the beverage, dairy and vegetable canning industries in the state. Of the 1.5 billion cans produced in Michigan in 1977, approximately 1.0 billion (67 percent) are estimated to have been beer and soft drink cans, and 0.5 billion (33 percent) were food cans.

Nationally, the can industry has experienced rapid technological changes since 1970 caused by the introduction of new can making technology--the two-piece can. These changes in can manufacturing technology have resulted in the closing of many can plants producing the traditional three-piece product and replacing and capacity with two-piece cans. There is evidence that this trend will continue, so that by 1981 about 80 percent of the beverage cans and a relatively small but growing percentage of other cans will be of two-piece construction. However, to date, no two-piece beverage can plants have been constructed in Michigan.

3.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on can manufacturing operation, estimated VOC emissions, the extent of current emission control and the likely alternatives which may be used for controlling VOC emissions in Michigan.

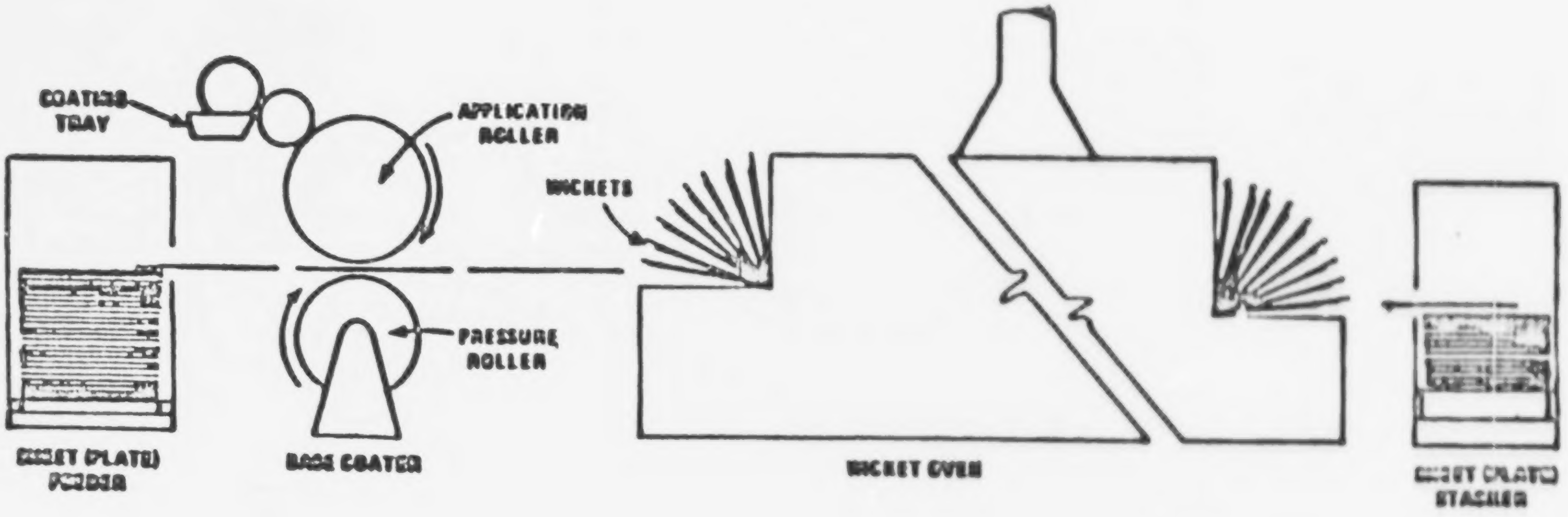
3.3.1 Can Manufacturing Operations

The can industry produces cans using two fundamental technologies, the traditional three-piece method and the newer two-piece technology.

The three-piece can technology consists of two separate operations: sheet coating and can fabrication (assembly). Sheet coating and can assembly operations are frequently performed in separate facilities. The major can manufacturers operate centralized facilties for the coating and decorating of flat sheets. These centralized plants are often called "feeder plants." (There were no feeder plants in Michigan during 1977.) Sheets are coated at a rate of about 2.5 base boxes per minute, which is equivalent to approximately 1,250 twelve-ounce cans per minute. The specific operations in three-piece can manufacture are summarized below.

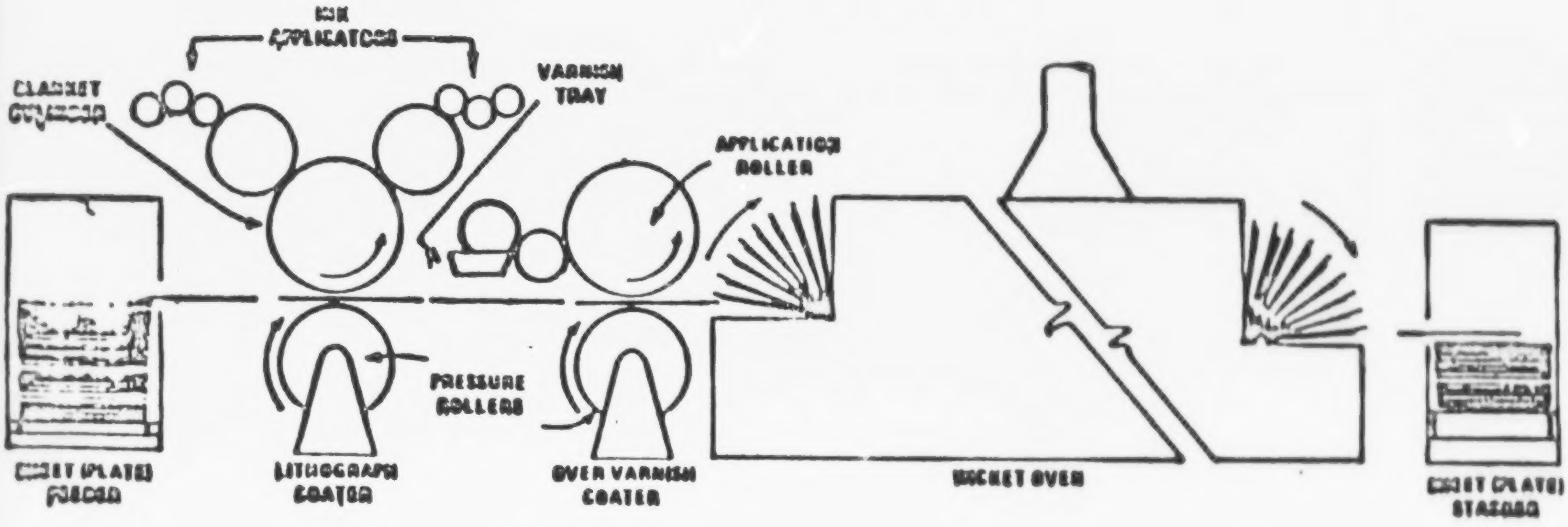
- Sheets of metal are coated and decorated with 28 or 35 can bodies (outs). This is accomplished in two steps.
    - The sheets are base coated on the interior side and then passed through a wicket oven.
    - Food cans, as well as some beer and soft drink cans, are given an exterior base coat.
    - In the case of beer and soft drink cans, the base coated sheets are decorated (printed), over coated with varnish and then cured in a smaller wicket oven.
    - Exhibits 3-3 and 3-4, on the following page, present flow diagrams of the base coating and decorating operations.

EXHIBIT 3-3
U.S. Environmental Protection Agency
SHEET BASE COATING OPERATION


COATING TRAY
APPLICATION ROLLER
WICKETS
PRESSURE ROLLER
SHEET (PLATE) FEEDER
BASE COATER
WICKET OVEN
SHEET (PLATE) STACKER

Source: U.S. Environmental Protection Agency

EXHIBIT 3-4
U.S. Environmental Protection Agency
SHEET PRINTING OPERATION


INK APPLICATORS
BLANKET CYLINDER
VARNISH TRAY
APPLICATION ROLLER
PRESSURE ROLLERS
SHEET (PLATE) FEEDER
LITHOGRAPH COATER
OVER VARNISH COATER
WICKET OVEN
SHEET (PLATE) STACKER

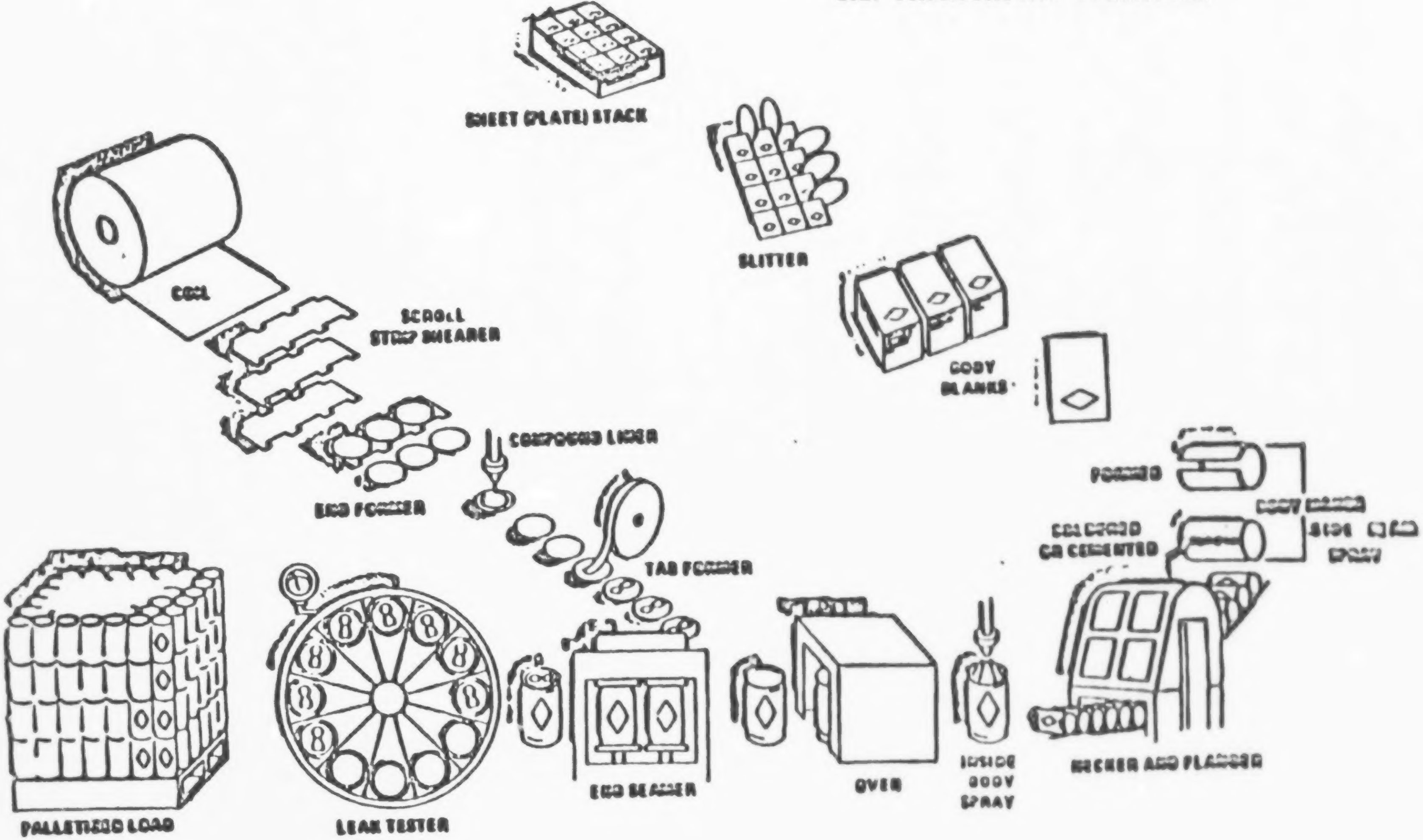
Source: U.S. Environmental Protection Agency

- Can bodies are formed from the coated sheets.
    - The printed sheets are slit into individual body blanks and fed into the "body maker."
    - The blank is rolled into a cylinder and soldered, welded or cemented.
    - The seam is sprayed (striped) on the inside and outside with an air dry lacquer to protect the exposed metal. Sometimes this is done only on the inside surfaces.
- Can ends are formed from coated sheet stock and fed to the end seamer where final fabrication is completed.
    - Can ends are stamped from coated stock and perimeter coated with synthetic rubber compound gasketing.
    - Solvent-based compounds are air-dried and water-based compounds are oven-dried.
- The can is fabricated from the body and the end in an "end sealer," leak tested and palletized for shipment. Exhibit 3-5, on the following page, presents a schematic of can end and three-piece can fabricating operations.

Two-piece cans are generally manufactured in an integrated high-speed process capable of producing 600 or 800 cans per minute.

- Coil stock is formed into a shallow cup.
- The cups are drawn and ironed into the form of a can.
- The cans are washed to remove the lubricant.
- An exterior base coat is applied (if required) by reverse roller coating and cured in a continuous oven.
- The cans are printed and then coated with a protective varnish. The coating is then baked in an oven. Steel cans are sometimes given two separate interior coatings.

EXHIBIT 3-5
U.S. Environmental Protection Agency
CAN END, AND THREE-PIECE BEER AND BEVERAGE CAN FABRICATING OPERATION


SHEET (PLATE) STACK
COIL
SLITTER
SCROLL STRIP SHEARER
BODY BLANKS
COMPOUND LINER
END FORMER
FORMED
BODY MAKER
SOLDERED OR CEMENTED
SIDE SEAM SPRAY
TAB FORMER
PALLETIZED LOAD
LEAK TESTER
END SEAMER
OVEN
INSIDE BODY SPRAY
NECKER AND FLANGER

Source: U.S. Environmental Protection Agency

- The cans are necked, flanged and tested.
- The interior of the cans are spray coated and baked in the oven.
- An exterior end spray coating is applied:
  - For aluminum cans to prevent blocking
  - For steel cans to prevent rusting.
- Exhibit 3-6, on the following page, is a process diagram of a two-piece can fabricating and coating operation.
- Two-piece cans are largely made from aluminum.
  - Virtually all aluminum cans are of two-piece construction.
  - Aluminum lends itself to two-piece construction, yet offers no advantage to warrant converting three-piece can lines to aluminum.

3.3.2 Emissions and Current Controls

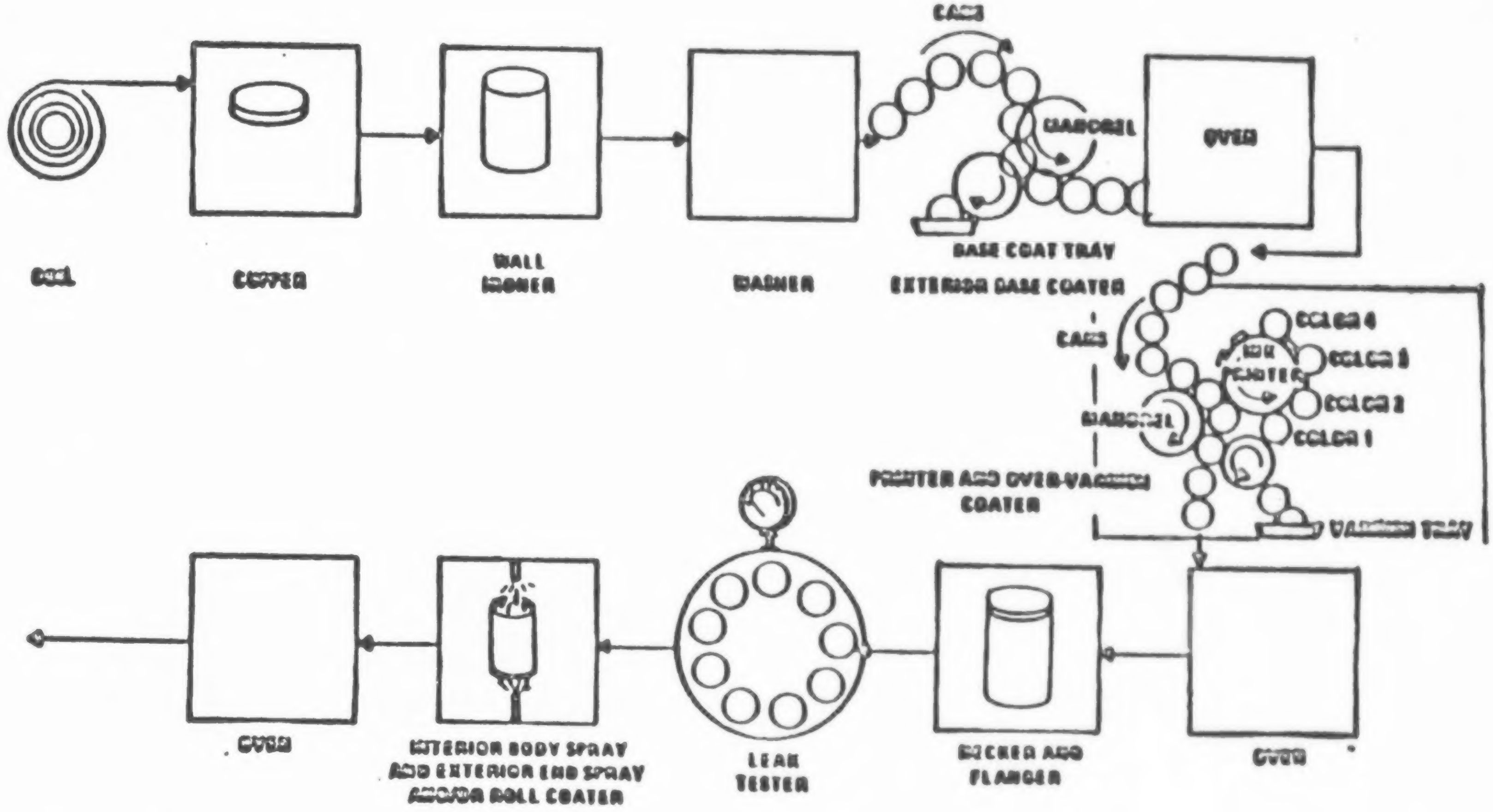
The can industry is moving toward products with inherently lower VOC emissions during manufacture. Differences in the manufacturing process between two-piece and three-piece cans allow for a 50 percent to 60 percent reduction in emissions in converting from a three-piece beer can to a two-piece beer can decorated in a similar manner. This is caused by a greater number of interior coating operations for three-piece cans, as well as a tendency to eliminate certain exterior coatings on two-piece beer and soft drink cans. The exhibits, on the following pages, present the emissions from typical can coating operations based upon average coating properties, can production rates and annual hours of operation. They present data for conventional systems, as well as for low solvent systems. It is important to note that, in most instances, can manufacturing does not require all the coatings.

- Exhibit 3-7 presents VOCs resulting from coating operations used in the manufacture of two-piece cans.
- Exhibit 3-8 presents VOCs resulting from sheet coating operations used in the manufacture of three-piece cans.
- Exhibit 3-9 presents VOCs resulting from typical three-piece can assembly operations.

EXHIBIT 3-6

U.S. Environmental Protection Agency

TWO-PIECE ALUMINUM CAN FABRICATING AND COATING OPERATION


COIL
CUPPER
WALL IRONER
WASHER
CANS
MANDREL
BASE COAT TRAY
EXTERIOR BASE COATER
OVEN
CANS
COLOR 4
COLOR 3
COLOR 2
COLOR 1
INK PRINTER
MANDREL
PRINTER AND OVER-VARNISH COATER
VARNISH TRAY
OVEN
NECKER AND FLANGER
LEAK TESTER
INTERIOR BODY SPRAY AND EXTERIOR END SPRAY AND/OR ROLL COATER
OVEN

Source: U.S. Environmental Protection Agency

EXHIBIT 3-7 (1)
U.S. Environmental Protection Agency
EMISSIONS FOR TYPICAL COATING
OPERATION USED IN THE MANUFACTURE
OF TWO-PIECE CANS

	Coating Properties							
Operation	Density (lb./gal.)	Solids (wt. %)	Organic Solvent (wt. %)	Organic Solvent (lb./gal.)	Water (gal./gal. coating)	VOC (lb. solvent/ gal. less water)	VOC (lb. solvent/ gal. incl. water)	Yield (1000 can/ gal.)
Organic Systems								
Print and varnish	8.0	45	100	4.40	0	4.40	4.40	12
Size and print	8.0	40	100	4.80	0	4.80	4.80	20
White base coat and print	11.0	62.5	100	4.13	0	4.13	4.13	9
Interior body spray	7.9	26	100	5.85	0	5.85	5.85	6[a]
End coating Al	8.0	45	100	4.40	0	4.40	4.40	200
End coating steel	8.0	45	100	4.40	0	4.40	4.40	40
Low Solvent Systems								
Waterborne								
Print and varnish	8.5	35	20	1.11	0.53	2.36	1.11	11
Size and print	8.5	30	20	1.19	0.57	2.76	1.19	17
White base coat and print	11.7	62	20	0.89	0.43	1.55	0.88	8
Interior body spray	8.55	20	20	1.37	0.66	3.99	1.36	5[a]
End coating Al	8.5	35	20	1.11	0.53	2.36	1.11	200
End coating steel	8.5	35	20	1.11	0.53	2.36	1.11	40
UV Cure High Solids								
Print and varnish[b]	8.0	95	100	0.40	0	0.40	0.40	25

EXHIBIT 3-7 (2)
U.S. Environmental Protection Agency

Operation	Production		Coating Consumed		VOC		
	(cans/min.)	(Million cans/yr.)	(gal./hr.)	(1000 gal./yr.)	(lb./hr.)	(tons/yr.)	(lb./million cans)
Organic Systems							
Print and varnish	650	253.5	3.25	21.1	14.3	46.5	364
Size and print	650	253.5	1.95	12.7	9.4	30.6	241
White base coat and print	650	253.5	4.33	28.1	17.8	57.9	457
Interior body spray	650	253.5	6.50	42.3	38.0	123.5	974
End coating Al	650	253.5	0.20	1.3	0.9	2.9	23
End coating steel	650	253.5	0.98	6.4	4.3	14.0	110
Low Solvent Systems							
Waterborne							
Print and varnish	650	253.5	3.55	23.1	3.9	12.7	100
Size and print	650	253.5	2.29	14.9	2.7	8.8	69
White base coat and print	650	253.5	4.88	31.7	4.3	14.0	110
Interior body spray	650	253.5	7.80	50.7	10.6	34.5	272
End coating Al	650	253.5	0.20	1.3	0.2	0.7	6
End coating steel	650	253.5	0.98	6.4	1.1	3.6	28
UV Cured High solids							
Print and varnish[b]	650	253.5	1.56	10.1	0.6	2.0	15

---

a. Assuming 75 percent beer cans, all given a single coat, and 25 percent soft drink cans, given a double coating

b. Booz, Allen & Hamilton Inc. estimate based on data supplied by CMI, individual can manufacturers and the EPA document 450/2-77-008

Source: Booz, Allen & Hamilton Inc. estimates based on data supplied by Can Manufacturers Institute and interviews with can companies.

EXHIBIT 3-8 (1)
U.S. Environmental Protection Agency
COATING AND PRINTING OPERATIONS USED IN
THE MANUFACTURE OF THREE-PIECE CANS
(Sheet Coating Operation)

Operation	Coating Properties							Dry Coating Thickness	
	Density (lb./gal.)	Solids (wt %)	Organic Solvent (wt %)	Organic Solvent (lb./gal.)	Water (gal/gal coating)	VOC (lb. solvent/ gal. less water)	VOC (lb. solvent/ gal. including water)	$\left(\frac{Mg}{4in^2}\right)$	$\left(\frac{lb.}{basebox}\right)$
Conventional Organics Systems									
Sizing and print	8.0	40	100	4.80	0	4.80	4.80	5	0.086
Inside basecoat	8.05	40	100	4.83	0	4.83	4.83	20	0.346
Outside white and print	11.0	62.5	100	4.13	0	4.13	4.13	40	0.692
Outside sheet printing and varnish	8.0	45	100	4.40	0	4.40	4.40	10	0.172
Low Solvent Systems									
Sizing (waterborne)	8.5	30	20	1.19	0.57	2.76	1.19	5	0.086
Inside basecoat									
High solids	8.0	80	100	1.60	0	1.60	1.60	20	0.346
Waterborne	8.8	40	20	1.06	0.51	2.15	1.05	20	0.346
Outside white									
High solids	12.0	80	100	2.40	0	2.40	2.40	40	0.692
Waterborne	11.7	62	20	0.89	0.43	1.55	0.88	40	0.692
Outside sheet print and varnish (waterborne)	8.5	35	20	1.11	0.53	2.36	1.11	10	0.172

EXHIBIT 3-8 (2)
U.S. Environmental Protection Agency

Operation	Production (base box / hr.)	Production (1000 base boxes[a] / year)	Coating Consumption (gallon / basebox)	Coating Consumption (gallon / hour)	Coating Consumption (1000 gal. / year)	VOC (lb. / hour)	VOC (tons / year)	VOC (lbs / 1000 base boxes)
Conventional Organics Systems								
Sizing and print	150	240	.027	4.1	6.6	19.7	15.8	130
Inside basecoat	150	240	.107	16.1	25.7	77.8	62.2	517
Outside white and print	150	240	.100	15.0	24.0	62.0	49.6	413
Outside sheet printing and varnish	150	240	.048	7.2	11.5	31.7		211
Low Solvent Systems								
Sizing (waterborne)	150	240	.034	5.1	8.1	6.1	4.9	41
Inside basecoat								
High solids	150	240	.054	8.1	13.0	13.0	10.4	87
Waterborne	150	240	.098	14.7	23.5	15.4	12.3	103
Outside white								
High solids	150	240	.072	10.8	17.3	25.9	20.7	172
Waterborne	150	240	.095	14.3	22.9	12.6	10.1	841
Outside sheet print and varnish waterborne)	150	240	.057	8.6	13.8	9.5	7.6	63

---

[a] Assuming 1,600 hours per year of operation.

Source: Booz, Allen & Hamilton Inc. estimates based on data supplied by CMI and individual can companies.

EXHIBIT 3-B (2)
U.S. Environmental Protection Agency

Operation	Production (base box / hr.)	Production (1000 base boxes^a / year)	Coating Consumption (gallon / basebox)	Coating Consumption (gallon / hour)	Coating Consumption (1000 gal. / year)	VOC (lb. / hour)	VOC (tons / year)	VOC (lbs / 1000 base boxes)
Conventional Organics Systems								
Sizing and print	150	240	.027	4.1	6.6	19.7	15.8	130
Inside basecoat	150	240	.107	16.1	25.7	77.8	62.2	517
Outside white and print	150	240	.100	15.0	24.0	62.0	49.6	413
Outside sheet printing and varnish	150	240	.048	7.2	11.5	31.7		211
Low Solvent Systems								
Sizing (waterborne)	150	240	.034	5.1	8.1	6.1	4.9	41
Inside basecoat								
High solids	150	240	.054	8.1	13.0	13.0	10.4	87
Waterborne	150	240	.098	14.7	23.5	15.4	12.3	103
Outside white								
High solids	150	240	.072	10.8	17.3	25.9	20.7	172
Waterborne	150	240	.095	14.3	22.9	12.6	10.1	841
Outside sheet print and varnish (waterborne)	150	240	.057	8.6	13.8	9.5	7.6	63

---

a. Assuming 1,600 hours per year of operation.

Source: Booz, Allen & Hamilton Inc. estimates based on data supplied by CMI and individual can companies.

EXHIBIT 3-9 (1)
U.S. Environmental Protection Agency
EMISSIONS OF TYPICAL COATING
OPERATIONS USED IN THREE-PIECE
CAN ASSEMBLY

	Coating Properties							
peration	Density (lb./gal.)	Solids (wt. %)	Organic Solvent (wt. %)	Organic Solvent (lb./gal.)	Water (gal./gal. coating)	VOC (lb. solvent/ gal. less water)	VOC (lb. solvent/ gal. incl. water)	Yield (1000 can/ gal.)
rganic Systems								
Interior body spray								
(beer)	7.9	26	100	5.85	0	5.85	5.85	4
Inside stripe								
(beer & bev.)	8.0	13.5	100	6.9	0	6.92	6.92	70
(food)	8.0	13.5	100	6.9	0	6.92	6.92	70
Outside stripe								
(beer)	8.0	13.5	100	6.9	0	6.92	6.92	50
End sealing compound								
(beer & bev.)	7.1	39	100	4.3	0	4.33	4.33	10
(food)	7.1	39	100	4.3	0	4.33	4.33	10
w Solvent Systems (water borne)								
Interior body spray								
(beer)	8.55	20	20	1.37	0.66	3.99	1.36	5
Inside stripe								
(beer & bev.)	8.55	36	20	1.09	0.53	2.30	1.08	70
(food)	8.55	36	20	1.09	0.53	2.30	1.08	70
Outside stirpe								
(beer)	8.55	36	20	1.09	0.53	2.30	1.08	45
End sealing compound								
(beer & bev.)[a]	9.00	40	3	0.16	0.63	0.43	0.16	10
(food)[a]	9.00	40	3	0.16	0.63	0.43	0.16	10

Reproduced from
best available copy.

EXHIBIT 3-9 (2)
U.S. Environmental Protection Agency

Operation	Production[b]		Coating Consumed		VOC		
	(cans/min.)	(Million cans/yr.)	(gal./hr.)	(1000 gal./yr.)	(lb./hr.)	(tons/yr.)	(lb./million cans)
Organic Systems							
Interior body spray (beer)	400	120	6.00	30.0	35.1	87.8	1,463
Inside stripe							
(beer & bev.)	400	120	0.30	1.5	2.1	5.3	88
(food)	400	72	0.30	0.9	2.1	3.2	88
Outside stripe (beer)	400	120	0.48	2.4	3.3	8.3	138
End sealing compound							
(beer & bev.)	400	120	2.40	12.0	10.4	26.0	433
(food)	400	72	2.40	7.2	10.4	15.6	433
Low Solvent Systems (Waterborne)							
Interior body spray (beer)	400	120	4.8	24.0	6.5	16.3	272
Inside stripe							
(beer & bev.)	400	120	0.30	1.5	0.3	0.8	13
(food)	400	72	0.30	0.9	0.3	0.5	13
Outside stripe (beer)	400	120	0.53	2.6	0.6	1.5	25
End sealing compound							
(beer & bev.)[a]	400	120	2.40	12.0	0.4	1.0	17
(food)[a]	400	72	2.40	7.2	0.4	0.6	17

---

a. Waterborne systems are currently only used on aerosol and oil cans.

b. Assumes 4,000 hours per year, as an average of 3,000 hours for food cans and 5,000 hours for beer and beverage cans.

Source: Booz, Allen & Hamilton Inc. estimates based on data supplied by CMI and individual can companies

The emissions from the industry, developed through the analysis of typical coating operations and the assumed product mix, total an uncontrolled level of 893 tons. Emissions from producing typical products are included in Exhibits 3-13 and 3-14 under the 1978 base case alternatives.

Can Type	Quantity (million)	VOC (tons/million)	Total VOC (tons)
3-piece beer and soft drink assembly with body spray	800	1.061	848
3-piece beer and soft drink assembly	200	0.113	23
3-piece food assembly	500	0.044	22
TOTAL			893

The following assumptions were made:

- All food cans were produced from precoated stock and precompounded ends. The only emission source was the inside stripe--88 pounds per million cans.
- 800 million beverage cans were produced from precoated and decorated stock. The emission sources were:
  - Inside stripe--88 pounds per million cans
  - Outside stripe--138 pounds per million cans
  - Inside spray--1,463 pounds per million cans
  - End compounding--433 pounds per million cans.
- 200 million beverage cans were produced from precoated and decorated stock and precompounded ends.
  - Inside stripe--88 pounds per million cans
  - Outside stripe--138 pounds per million cans.

The data supplied in the Michigan emissions inventory and developed during the interviews indicate that the industry is generally not incinerating emissions at plants in Michigan. However, the industry may be using waterborne and also exempt solvents as defined by Rule 66; use of exempt solvents is not an acceptable approach under RACT.

Exhibit 3-10, on the following page, shows the total emissions from three can manufacturing facilities to be about 925 tons per year. The source of this emission data is the Michigan emission inventory. These data appear to be incomplete and include facilities that are not normally included in the can manufacturing industry--SIC 3411. The three can manufacturing facilities identified were:

- Continental Can Company; Canton Twp.
- National Can Company; Livonia
- Diversified Packages; Howell.

Four other facilities that were identified are generally not considered can manufacturers:

- Alfab; Albio
- Great Lakes Container Co.; Detroit
- Great Lakes Container Co.; Detroit
- Tri-State Engineering; Adrian.

These four plants represent 225 tons of VOC emissions; however, these emissions are not included in this analysis.

3.3.3 RACT Guidelines

The RACT Guidelines for VOC emission control are specified as the amount of allowable VOC, in pounds per gallon of coating, minus any water in the solvent system. To achieve this guideline, RACT suggests the following options:

- Low solvent coatings
    - Waterborne
    - High solids
    - Powder coating
    - Ultraviolet curing of high solids coatings
- Incineration
- Carbon adsorption.

The RACT guidelines have established different limitations for each of four groups of can coating operations. Exhibit 3-11, following Exhibit 3-10, presents the recommended VOC limitations, compared with typical, currently available, conventional coatings.

EXHIBIT 3-10
U.S. Environmental Protection Agency
MICHIGAN EMISSIONS--CAN COATING

Establishment Code	SIC Code	Company Name, Location	Employees	Equip. Code	Process	Thruput Quantity (gal.)	Emissions (tons/yr.)	Emissions Factor (lb./gal.)	Ract (lb./gal.)
A0384	3411	Continental Can Company 50625 Cherry Hill Road Canton Twp., Michigan 48197	-	0043	Lacquer Spray	45,500	132.86	5.84	2.8
B1130	3411	National Can Corporation 13000 Levan Road	61	0049	In/Out Strip	22,314	62.81	5.63	-
				0043	Spray Machine	100,509	293.49	5.84	-
						122,823	356.30		
B2309	3411	Diversified Packagers Howell, Michigan 48843	124	0049	Spray Coatings	90,800	255.60	5.63	-
				0049	Post Strip	13,900	39.13	5.63	-
				0057	End Compound	50,000	140.75	5.63	-
						154,700	435.48		
							924.64		

Source: Booz, Allen & Hamilton Inc. analysis of Michigan Emission Inventory

EXHIBIT 3-11
U.S. Environmental Protection Agency
RACT GUIDELINES FOR CAN COATING OPERATIONS

Coating Operation	Recommended Limitation		Typical Currently Available Conventional Coatings
	kg. per liter of coating (minus water)	lbs. per gallon of coating (minus water)	lbs. per gallon of coating (minus water)
Sheet basecoat (exterior and interior) and overvarnish; two-piece can exterior (basecoat and overvarnish)	0.34	2.8	4.1-5.5
Two- and three-piece can interior body spray, two-piece can exterior end (spray or roll coat)	0.51	4.2	6.0
Three-piece can side-seam spray	0.66	5.5	7.0
End sealing compound	0.44	3.7	4.3

Source: U.S. Environmental Protection Agency

3.3.4 Selection of the Most Likely RACT Alternatives

Projecting the most likely industry response for control of VOC emissions in can manufacturing facilities is complicated by the thousands of different products offered by the can industry. Based on industry interviews, several general assumptions can be made regarding the industry in Michigan as well as nationally.

- The industry preferred response will be to use low solvent coatings (primarily waterborne) wherever technically feasible because of their low cost--see incremental cost comparisons on Exhibits 3-13 and 3-14.
  - The choice between thermal incinerators and catalytic incinerators will be based on the availability of fuel and the preference of the individual companies.
  - Incinerators with primary heat recovery will be used in preference to those with secondary recovery or no heat recovery.
- The industry will not install carbon adsorption systems because of the very poor performance record established to date in several can plants that have evaluated this control approach.
- Six likely control alternatives, as well as two base cases, are discussed in the paragraphs below. The percentage of cans likely to be manufactured by each of the control option alternatives, by 1982, is summarized in Exhibit 3-12, on the following page. The resulting emissions are summarized in Exhibits 3-13 and 3-14, at the end of this section. For cases involving incineration, the following estimates were made.
  - Energy cost is $2.25 per million BTUs.
  - Capital cost is $20,000 per thousand CFM.
  - Incinerators operate at 10 percent of the lower explosive limit.
  - 90 percent of the roller coating emissions are collected and incinerated.
  - 30 percent of the interior spray coating emissions are collected and incinerated.

EXHIBIT 3-12

U.S. Environmental Protection Agency

ESTIMATED PERCENTAGE OF CANS

TO BE MANUFACTURED IN 1982

USING EACH VOC CONTROL ALTERNATIVE

Type Of Can Manufactured	Waterborne Or Other Low Solvent Coatings	Thermal Incineration With Primary Heat Recovery	Print Only, All Low Solvent Coatings	Low Solvent Coatings Except End Sealant Which is Incinerated	UV Cured Outside Varnish Waterborne Inside Spray
2-piece beer and soft drink	--	--	--	--	--
3-piece beer and soft drink	70	10	--	20	--
3-piece food and other cans	50	50	--	0	--

Source: Booz, Allen & Hamilton Inc.

The assumptions on cost operating parameters and likely industry response to each control alternative were based upon discussions with knowledgeable industry sources and on Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories.

3.3.4.1 Three-Piece Beer and Soft Drink Cans--Base Case

At the present time, the majority of three-piece beer and soft drink cans are produced by the following coating operations:

- Interior base coat
- Decoration and over varnish
- Interior and exterior stripe
- Interior spray coating
- End sealant.

The production of beer cans differs from the production of soft drink cans in some respects that have not been considered in this study.

- Beer cans almost always have an exterior stripe, but soft drink cans frequently do not.

- Beer cans always have an inside spray coating but soft drink cans usually do not. However, soft drink cans frequently have a heavier inside base coat to offset the elimination of the spray coating.

Consideration of these differences has been eliminated to reduce the complexity of the study. Because of the declining importance of three-piece beer and beverage cans, the impact will be smaller in 1982 than it would be currently.

The total emissions from this alternative are 1.79 tons per million cans (2.5 times the emissions from a similar two-piece can).

3.3.4.2 Three-Piece Beer and Soft Drink Cans--Waterborne Coatings as Proposed by RACT

In this alternative, all the coating operations currently employed in the base case have been converted to waterborne coatings. The cost of converting to waterborne systems was assumed to be minimal.

- The capital cost for converting each of five coating operations was assumed to be $10,000. This results in an annualized capital cost of $104 per million cans--assuming that the cost of capital and maintenance is 25 percent of the total installed capital cost and that 120 million cans are produced annually on the coating line.

- The raw material cost of coatings is the same as for conventional coatings.

- The energy consumption is the same--this would appear reasonable since most of the energy is consumed to heat the wickets and belts and also the metal.

- The yield (spoilage) is the same--it appears that the industry will continue to encounter significant spoilage in changing over to new coatings. However, as the technology is established, it is assumed that spoilage will decline to currently acceptable levels.

The total incremental cost to convert to waterborne coatings is estimated to be about $100 per million cans. This represents a cost increase of about 0.15 percent. The emissions would be reduced to 0.34 tons per million cans, an 80 percent reduction at a cost of about $72 per ton.

It is estimated that 70 percent of all beer and soft drink facilities will employ this option. The acceptance of this technology will be retarded by the lack of a complete line of available coatings.

3.3.4.3 Three-Piece Beer and Soft Drink Cans--Base Case with Thermal Incinerators and Primary Heat Recovery

This alternative assumes that all coating operations currently employed in the base case are retrofitted with thermal incinerators. At least one thermal incinerator is currently being employed on a coating line in Michigan.

The capital required for five incinerators would be about $320,000--assuming an installed cost of $20,000 per thousand CFM.

- The annualized capital cost would be about $668 per million cans.

- The energy cost to operate the incinerators would be $166 per million cans.

- The material cost would be the same as the base case.

The total incremental cost of adopting thermal incineration is estimated to be about $834 per million cans. This represents a cost increase of about 0.2 percent. The emissions would be reduced by 59 percent to 0.74 tons per million cans at a cost of $794 per ton of emissions removed. Because of the prohibitively high costs of this alternative, it is estimated that it will be employed only on 10 percent of all three-piece beer and soft drink cans manufactured in Michigan in 1982.

3.3.4.4 Three-Piece Beer and Soft Drink Cans--All Waterborne Except End Sealant, which is Thermally Incinerated

It is likely that the can industry will adopt a hybrid system which will focus on waterborne or possibly other low solvent coatings and thermal incineration of the end sealant and which probably will not be universally available by 1982. Because end sealing compounds represent approximately 12 percent of the VOC from three-piece beer and soft drink can manufacture, this case was developed under the assumption that technology-based exceptions will not be granted.

- The capital cost of converting four coating operations and adding one incinerator would be about $340 per million cans.
- The additional energy costs of one incinerator would be about $93 per million cans.
- Material cost would be the same.

The total incremental cost of this scenario would be about $171 per million cans. This represents a cost increase of about 0.2 percent, to reduce emissions by 80 percent. It is estimated that about 20 percent of the beer and soft drink cans will be produced using this technology. (This does not include cans that are precoated with noncomplying coatings in other states.)

3.3.4.5 Three-Piece Food Cans--Base Case

Three-piece food cans are currently produced utilizing the following coating operations:

- Interior base coat
- Exterior base coat
- Interior stripe
- End sealant.

The emissions from this case are estimated to be 0.99 tons per million cans.

3.3.4.6 Three-Piece Food Cans--Waterborne as Proposed in RACT

In this alternative, all the coating operations currently employed in the base case have been converted to waterborne coatings.

The total incremental cost to convert to waterborne coatings is estimated to be $113 per million cans. A 76 percent reduction in emissions is achieved, to 0.24 tons per million cans. It is unlikely that a complete spectrum of waterborne coatings will be available to meet industry requirements by 1982 because:

- The focus of research is on two-piece beer and soft drink cans, which is the most rapidly growing market segment.
- The need to achieve FDA approval for the broad spectrum of products needed to meet diverse requirements has also caused coating manufacturers to focus on the large-volume coatings required for beer and soft drinks.

As a result, it is estimated that only 50 percent of the cans will be produced using this control approach. (This category includes noncomplying coatings that are applied in feeder plants located in other states.)

3.3.4.7 Three-Piece Food Cans--Base Case with Thermal Incinerators and Primary Heat Recovery

This alternative assumes that all coating operations currently employed in the base case are retrofitted with thermal incinerators.

The total incremental cost of adopting this approach is estimated to be about $690 per million cans, $595 in capital cost and $95 in energy costs. Emissions would be reduced by 81 percent, to 0.19 tons per million cans. An estimated 50 percent of the cans would be produced using this approach.

3.3.4.8 Three-Piece Food Cans--All Waterborne Except End Sealant, Which Is Thermally Incinerated

Because waterborne and other low solvent coatings are not available, it is likely that the industry will develop a hybrid approach utilizing waterborne coatings where available and incinerating the balance. The end sealing compound appears to be the coating most likely to be unavailable in low solvent form by 1982--end sealing compounds released about 18 percent of the VOC emissions from food can manufacturing operations.

The total incremental cost of this scenario is about $200 per million cans; $192 in capital cost and $17 in energy costs. The emissions are reduced by about 79 percent to 0.25 tons per million cans. It is estimated that no cans would be produced using this approach; cans would be precoated with noncomplying coatings in other states.

EXHIBIT 3-13
U.S. Environmental Protection Agency
EMISSIONS FROM COATING TWO-PIECE ALUMINUM BEER AND SOFT DRINK CANS PER MILLION CANS

Alternative	Capital ($)	Annualized Incremental Costs: Annualized Capital Cost ($)	Materials ($)	Energy ($)	Total ($)	Coating Input (gal.)	Emissions: VOC Emissions (tons)	VOC Decrease (tons)	VOC Decrease %	Incremental Cost (per ton)
1978 BASE CASE Print and varnish Nonconfirming interior body spray (exempt solvents) End coating	0	0	0	0	0	250	0.67	a	a	a
WATERBORNE AS PROPOSED IN RACT	120	30	0	0	30	340	0.19	0.48	75	63
BASE CASE WITH THERMAL INCINERATORS & PRIMARY HEAT RECOVERY	266	66	0	62	128	250	0.39	0.29	42	441
SUPPLEMENTAL SCENARIO 1 Print only Waterborne interior body spray End coating using a low varnish solvent	80	20	(540)	(230)	(750)	200	0.14	0.53	79	(1,415)
SUPPLEMENTAL SCENARIO 2 Print UV cured varnish Waterborne interior body spray End coating using a low solvent varnish	120	30	810	105	734	240	0.15	0.52	78	1,411

---

a. Not applicable

Source: Booz, Allen & Hamilton Inc. estimates

EXHIBIT 3-14
U.S. Environmental Protection Agency
EMISSIONS FROM COATING THREE-PIECE CANS
PER MILLION CANS

Case	Annualized Incremental Costs					Coating And Emissions				
	Capital ($)	Annualized Capital Cost/Millions ($)	Materials ($)	Energy ($)	Total ($)	Coating Input (gal.)	VOC Emissions (tons)	VOC Decrease (tons)	VOC Decrease %	Incremental Cost ($ per ton)
BEVERAGE CANS										
1978 BASE CASE Interior base coat Decoration and/or varnish Interioring and exterior stripe Interior spray End sealant	0	0	0	0	0	894	1.79	a	a	a
WATERBORNE AS PROPOSED IN RACT	416	104	0	0	104	720	0.34	1.45	81	72
BASE CASE WITH THERMAL INCINERATORS AND HEAT RECOVERY PRIMARY	2,670	668	0	166	834	694	0.74	1.05	59	794
SUPPLEMENTAL SCENARIO 3 Waterborne except end sealant which is incinerated	686	171	0	20	191	715	0.35	1.44	80	133
FOOD CANS										
1978 BASE COAT Interior base coat Exterior base coat Interior stripe End sealant	0	0	0	0	0	424	0.99	a	a	a
WATERBORNE AS PROPOSED IN RACT	453	113	0	95	687	439	0.24	0.75	76	151
BASE CASE WITH THERMAL INCINERATORS AND PRIMARY HEAT RECOVERY	2,380	595	0	95	687	424	0.19	0.80	81	859
SUPPLEMENTAL SCENARIO 4 All waterborne except end sealant which is incinerated	768	192	0	17	209	435	0.23	0.76	77	275

---

a. Not applicable.

Source: Booz, Allen & Hamilton Inc. estimates.

3.4 COST AND VOC BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Costs for alternative VOC emission controls are presented in this section, based upon the costs per million cans developed for each alternative in the previous section. The extrapolation is based upon can production and emissions for actual can manufacturing processes and not upon the representative plants.

3.4.1 Costs for Alternative Control Systems

Although there is no typical can manufacturing facility, the following representative plants describe the situation in most can manufacturing facilities.

- Representative Plant A produces 80 percent three-piece beer and soft drink cans and 20 percent three-piece food cans using three assembly lines. Each can assembly line operates at 400 cans per minute, the beer lines for 5,000 hours annually and the food can lines for 3,000 hours annually.

- Representative Plant B produces food cans from precoated stock. It contains two can assembly lines, each of which operates at 400 cans per minute for 3,000 hours annually. The total plant production is 144 million cans.

The capital cost to adopt the alternative controls to the two representative plants ranges from $20,000 (to convert the can assembly plant to waterborne coatings) to $160,000 (to retrofit the three-line assembly plant with incinerators). The incremental operating costs (energy plus 25 percent of capital) range from $5,000 for operating the small food can assembly plant with waterborne coatings to about $150,000 for operating incinerators at the larger three-piece assembly plant. Capital and annual operating costs for each of the representative plants is presented for each applicable alternative on Exhibit 3-15, on the following page.

3.4.2 Extrapolation of the Costs to the Statewide Industry

The costs developed are incremental costs based on the production volume and mix estimate for 1977. Industry changes related to plant closing, conversion to two-piece lines, consumption patterns or other areas not directly related to RACT implementation were not included. One exception is that the trend to print-only on existing lines was addressed and the portion allocated to RACT was estimated and included in the final figures.

EXHIBIT 3-15

U.S. Environmental Protection Agency
COST OF IMPLEMENTING RACT ALTERNATIVES FOR
REPRESENTATIVE CAN MANUFACTURING PLANTS ($1,000)

Representative Plant	Waterborne		Thermal Incinerators		Print Only/Waterborne		UV Cured/Waterborne		Waterborne Incinerated End Sealant	
	Capital	Annual Expense	Capital	Annual Expense	Capital	Annual Expense	Capital	Annual Expense	Capital	Annual Expense
A. 3-piece beer & soft drink and food can	80	20	160	150	a	a	b	b	82	42
B. Food can assembly plant 2 assembly lines with inside striping 144 million cans	20	5	60	20	a	a	b	b	a	a

---

a. Not applicable
b. Not considered to be a likely response by 1982

Source: Booz, Allen & Hamilton Inc. estimates

The can manufacturing industry in Michigan is part of an integrated nationwide network (the greatest volume of cans are produced by firms with nationwide operations for customers who source their products nationwide), of facilities using established and nonproprietary technology. Therefore, Michigan costs can be readily estimated from data developed on a nationwide basis.

Extrapolation of the costs to the statewide industry requires, first, segmenting the industry in Michigan according to the types and number of major cans produced, quantifying emissions from each type of can production and identifying the 1977 level of controls, if any, to develop a 1977 baseline case. Second, the likely industry response to the regulations must be developed; and finally, the cost of implementing this response must be calculated. The data and estimates necessary to perform this extrapolation have been presented in previous sections.

- Can production (in units) by type was presented in section 3.2.3.
- Emissions (per million cans) from the production of cans using the various coating operations were presented in Exhibits 3-7, 3-8 and 3-9 and combined on Exhibits 3-13 and 3-14, for several control alternatives for the major types of cans.
- Theoretical uncontrolled emissions were calculated by multiplying the number of cans of each type by the 1977 base case alternative on Exhibits 3-13 and 3-14. This estimate of 893 tons was presented in section 3.3.2.
- The 1977 base line level was assumed to be the theoretical uncontrolled level since no incineration or low solvent coatings were used. (Low solvent coatings were used in 1978.)

The industry response in 1982 to the RACT alternative was presented in section 3.3.4 and summarized on Exhibit 3-12. It included a discussion of the cost and emission reductions from the theoretical level of uncontrolled emission. Exhibit 3-16, on the following page, shows that likely industry capital expenditures of $0.4 million will be required to comply with RACT. The annual compliance cost is estimated at $160,000. It is estimated that emissions will be reduced by 709 tons from the theoretically uncontrolled level and baseline of 893 tons.

Annual average unit cost of emission reduction is estimated to be $230 per ton. Three-piece food and other can assembly has a high unit cost, $2,444 per ton.

EXHIBIT 3-16 (1)
U.S. Environmental Protection Agency
COST OF COMPLIANCE TO RACT FOR THE
CAN MANUFACTURING INDUSTRY IN MICHIGAN

Can Type	Can Production (millions of units)				Capital Investment ($ thousand)			
	Waterborne Or Other Low Solvent Coatings	Thermal Incineration With Primary Heat Recovery	Low Solvent Coatings Except End Sealant Which Is Incinerated	Total	Waterborne Or Other Low Solvent Coatings	Thermal Incineration With Primary Heat Recovery	Low Solvent Coatings Except End Sealant Which Is Incinerated	Total
3-Piece Beer and Soft Drink	700	100	200	1,000	180	50	53	283
3-Piece Food and Other Cans	250	250	0	500	40	104	0	144
TOTAL				1,500				427

EXHIBIT 3-16 (2)
U.S. Environmental Protection Agency

Can Type	Annual Compliance Cost ($ thousand)				Emission Reduction (tons)				
	Waterborne Or Other Low Solvent Coatings	Thermal Incineration With Primary Heat Recovery	Low Solvent Coatings Except End Sealant Which Is Incinerated	Total	Waterborne Or Other Low Solvent Coatings	Thermal Incineration With Primary Heat Recovery	Low Solvent Coatings Except End Sealant Which Is Incinerated	Total	Unit Cost Of Emission Reduction ($ per ton)
3-Piece Beer and Soft Drink	45	48	26	119	515	29	147	691	172
3-Piece Food and Other Cans	10	34	0	44	9	9	0	18	2,444
Subtotal	55	82	26	163	524	38	147	709	230
Less Controls in Place	0	0	0	0	0	0	0	0	0
Less Product Changes	a	a	a	0	a	a	a	0	0
TOTAL RACT	55	82	26	163	524	38	147	709	230

---

a. Not applicable

Source: Booz, Allen & Hamilton Inc.

3.5 DIRECT ECONOMIC IMPLICATIONS

This section presents the direct economic implications of implementing RACT controls to the statewide industry, including: availability of equipment and capital; feasibility of the control technology; and impact on economic indicators such as value of shipments, unit price, state economic variables and capital investment.

3.5.1 RACT Timing

RACT must be implemented statewide by January 1, 1982. This implies that can manufacturers must have either low solvent coatings or VOC control equipment installed and operating within the next three years. The timing of RACT imposes several requirements on can manufacturers including:

- Obtaining development quantities of low solvent coatings from their suppliers and having them approved by their customers
- Having coating makers obtain FDA approval where necessary
- Obtaining low solvent coatings in sufficient quantity to meet their volume requirements
- Acquiring the necessary VOC control equipment
- Installing and testing incinerators or other VOC control equipment to insure that the system complies with RACT.

The sections which follow discuss the feasibility and the economic implications of implementing RACT within the required timeframe.

3.5.2 Feasibility Issues

Technical and economic feasibility issues implementing RACT controls are discussed in this section.

The can manufacturing industry, in conjunction with coating suppliers and incinerator vendors, has extensively evaluated most of the approaches to meeting RACT. The feeling in the inudstry is that, but for one notable exception, RACT can be achieved by January 1, 1982, using low solvent coatings--primarily waterborne. The coating most likely to be unavailable in 1982 is the end sealing compound. The physical characteristics of this material, as well as its method of application, do not lend themselves to incineration. Currently, the coating is air dried over a period of 24 hours.

The can manufacturers have shut down a significant number of three-piece can manufacturing facilities. It appears likely that the implementation of RACT will accelerate this trend because of the lower cost of compliance with two-piece cans and the probable reluctance on the part of can manufacturers to invest capital in facilities producing products with declining demand.

3.5.3 Comparison of Direct Cost with Selected Direct Economic Indicators

This section presents a comparison of the net increase in the annualized cost of implementing RACT with the total value of cans sold in the state, the value of wholesale trade in the state and the unit price of cans.

The net incremental annualized cost to can manufacturers is estimated to be about $163,000 (0.14 percent of the value of shipments).

3.5.4 Ancillary Issues Relating to the Impact of RACT

This section presents two related issues that were developed during the study.

The can manufacturers are seeking to have the guidelines altered to encompass a plantwide emissions basis. This would allow a credit from one operation, where emissions were reduced to below the RACT recommended level, to be applied to another operation that is not in compliance. The plant would be in compliance if the total emissions were reduced to the level proposed in RACT. It appears that the impact of this proposed regulation, if accepted, would be to further concentrate the difficult-to-control emissions, such as ending sealing compounds, while reducing other emission sources to below the recommended RACT requirements. The net effect would be equivalent emissions at a lower compliance cost.

High solvent coatings represent a considerable fire hazard. The conversion to low solvent coatings has reduced fire insurance costs for at least one can manufacturing facility.

* * * *

Exhibit 3-17, on the following page, presents a summary of the current economic implications of implementing RACT for can manufacturing plants in the State of Michigan.

EXHIBIT 3-17 (1)

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR CAN MANUFACTURING PLANTS IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	There are five can manufacturing facilities
Indication of relative importance of industrial section to state economy	1977 value of shipments was $110 million. Industry is closely related to state's food, dairy and beverage industries
Current industry technology trends	Beer and beverage containers rapidly changing to two-piece construction
1977 VOC emissions (actual)	900 tons per year (the industry reportedly has no emission controls in place in 1977)
Industry preferred method of VOC control to meet RACT guidelines	Low solvent coatings (waterborne)
Assumed method of control to meet RACT guidelines	75 percent of cans coated with low solvent coatings; 25 percent of coated cans requiring incinerator for control

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$430,000 (approximately 10 percent of current annual capital appropriations for the industry)
Annualized cost (statewide)	$160,000 (approximately 0.14 percent of the industry's 1977 statewide value of shipments)
Price	Assuming a "direct cost pass through" less than $0.002 can increase (based on a can value of $0.085 per can)
Energy	Increase of 3,250 equivalent barrels of oil annually for operation of facilities that have to utilize incinerators
Productivity	No major impact
Employment	No major impact

EXHIBIT 3-17 (2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
Market structure	Accelerated technology conversion to two-piece cans, further concentration of sheet coating operations into larger facilities
RACT timing requirements (1982)	Low solvent coating volume requirements and FDA approval may require some facilities to meet the RACT requirements with incineration (rather than low solvent coating technology)
Problem area	Low solvent coating technology for end sealing compound
VOC emission after RACT control	200 tons per year (21 percent of 1977 emission level)
Cost effectiveness of RACT control	$225 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Control of Volatile Organic Emissions from Existing Stationary Sources, EPA-450/2-77-008, May 1977.

Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories

Private conversations with the following:

American Can Company, Greenwich, Connecticut
Continental Can Company, Chicago, Illinois
Heekin Can Company, Augusta, Wisconsin
National Can Company, Chicago, Illinois
Libby McNeil & Libby, Baraboo, Wisconsin
Joseph Schlitz Brewing Company, Oak Creek, Wisconsin
Carnation Company, Waupam, Wisconsin
Campbell Soup Company, Napoleon, Ohio
Green Giant Company, Ripon, Wisconsin
Fall River Canning Company, Fall River, Wisconsin
Miller Brewing Company, Miller, Wisconsin
Ocononowoc Canning Company, DeForest, Wisconsin
Diversified Packagers, Howell, Michigan
Can Manufacturers Institute, Washington, D.C.

4.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT TO THE SURFACE COATING OF COILS IN THE STATE OF MICHIGAN

4.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT TO THE SURFACE COATING OF COILS IN THE STATE OF MICHIGAN

As will be shown in this chapter, there will be little or no economic impact resulting from the implementation of RACT standards to the coil coating business in the state of Michigan. This is due, primarily, to the current existence of adequate VOC emission control methods at most of the manufacturing facilities.

This chapter is divided into four sections:

- Specific methodology and quality of estimates
- Applicable RACT guidelines and control technology
- Coil coating operations in the state of Michigan
- Direct economic implications.

4.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Economic impacts

for the surface coating of coils in Michigan.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

4.1.1 Industry Statistics

Coil coating is listed under Standard Industrial Classification (SIC) 3479. Our methodology to gather statewide statistical data on coil coating in Michigan was as follows:

- A list of potentially affected facilities was compiled from the state emission inventory.

- Interviews were performed with those companies appearing on the list of emitters to validate their participation in this industry sector (this list was not 100 percent validated).

Because the majority of coil coating operations are captive, data on the value of shipments were not available. Also the number of employees in this industry category were not available.

4.1.2 VOC Emissions

Booz, Allen developed a listing of four facilities, identified as hydrocarbon emitters in the surface coating of coils covered by RACT in the state of Michigan. This listing of industries subject to RACT guidelines for hydrocarbon emissions and the emission data are based on information provided by the 1977 Michigan Air Pollution Reporting form instructions. The list, therefore, may not be all inclusive, or it may include some industries that may not be actually performing the coating operations indicated or identified by the RACT category. Sufficient data and resources were not available to verify each listing. The emissions for 1977 and only those facilities with greater than two tons per year emission are included.

4.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions for the surface coating of coils are described in Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II; Surface Coatings of Cans, Coils, Paper, Fabrics, Automobiles and Light Duty Trucks, EPA-405/2-77-008, May 1977.

4.1.4 Cost of Control of VOC Emissions for Surface Coating of Coils

The costs of control of volatile organic emissions for surface coating of coils were developed by:

- Determining the alternative types of control systems likely to be used
- Estimating the probable use of each type of control system
- Defining system components
- Developing installed capital costs for each alternative control system
- Defining a model plant
- Developing costs of a control system for the model plant:
  - Installed capital cost
  - Direct operating cost
  - Annual capital charges
  - Energy requirements
- Extrapolating model costs to individual industry sectors
- Aggregating costs to the total industry for the state.

4.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements to implement RACT, assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Michigan.

4.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of coils in Michigan. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that are published for the base year), "B" indicates data that were extrapolated from hard data and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 4-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 4-1
U.S. Environmental Protection Agency
SURFACE COATING OF COILS
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics			X
Emissions		X	
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

4.2 APPLICABLE RACT STANDARDS AND CONTROL TECHNOLOGY

This section includes a review of:

- Applicable RACT standards
- The technology of coil coating
- Commercial aspects of the business
- Approved control technologies
- Estimated capital and operating costs to control VOC emissions.

4.2.1 Approved RACT Standards

As indicated in the EPA guidelines (EPA 905/2-78-001, April, 1978) Article XX.9204, subpart (d) (1):

> ...no owner or operator of a coil coating line... may cause, allow or permit discharge into the atmosphere of any volatile organic compounds in excess of 0.31 kilograms per liter of coating (2.6 pounds per gallon), excluding water, delivered to the coating applicator from prime and topcoat or single coat operations.

Thus, of the approximately 4 to 6 pounds of VOC contained in a gallon of paint to be applied with coil coating techniques, the operator must not allow emission of more than 2.6 pounds. The reduction in emissions may be achieved by utilization of low solvent content coating technology, thermal incineration or other approved methods.

4.2.2 The Technology of Coil Coating

Coil coating is the coating of any flat metal (aluminum or steel typically) sheet or strip that comes in rolls or coils. This process consists of taking the coil through a series of steps in one continuous process. Generally, these steps include:[1]

- Cleaning--removal of mill-applied protective oils, dirt, rust and scale
- Rinsing--removal of the products of the cleaning process
- Pretreating--with chemicals such as iron and zinc phosphates, chromates and complex oxides to prepare the metal for coatings
- Rinsing--after the pretreatment

---

[1] National Coil Coaters Association brochure

- Painting--commonly by application of primer and finish coats with a "reverse" roller technique in which the roll applying the coating turns in the opposite direction of the metal being coated

- Curing--all coatings are cured in seconds as they pass through ovens, mostly of the convention or heat air type. At the end of the curing operation, the coated metal is recoiled for shipment.

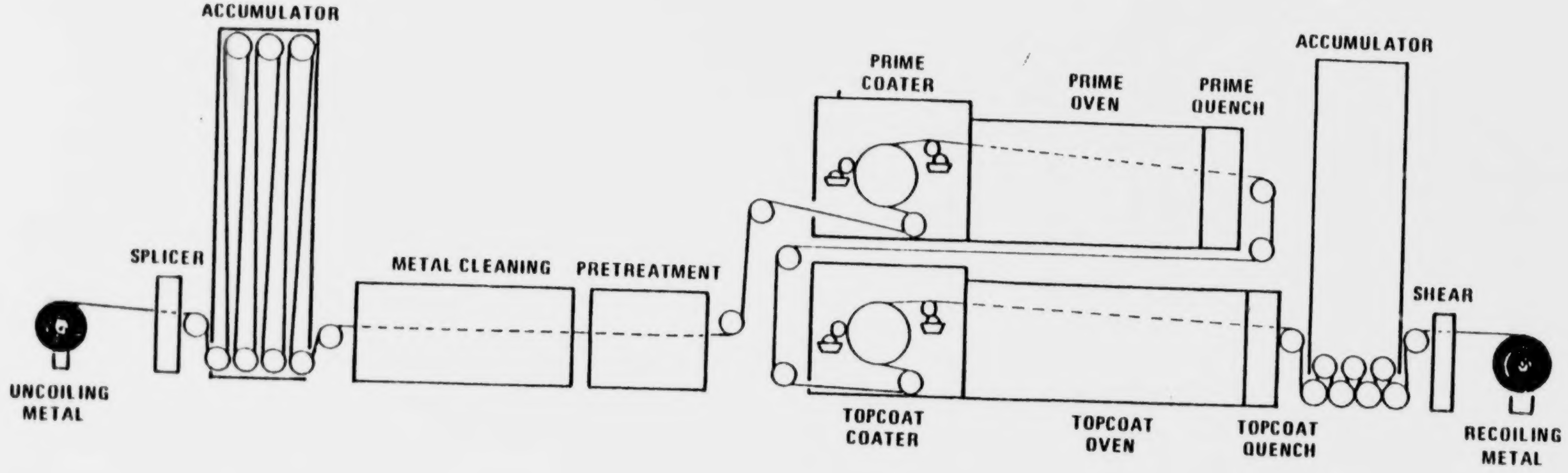
Configurations of coil coating lines differ. On some lines, the metal is uncoiled at one end of the line and recoiled at the opposite end. On other lines, called "wrap around" lines, the metal is uncoiled and recoiled at about the same point on the line. Some coil coating lines have a single coater and one curing or baking oven; others, called "tandem" lines, have several successive coaters each followed by an oven, so that several different coatings may be applied in a single pass. Exhibit 4-2, on the following page, is a schematic of a "tandem" coil coating line.

The metal on the coil coating line is moved through the line by power-driven rollers. It is uncoiled as the process begins and goes through a splicer, which joins one coil of metal to the end of another coil for continuous, nonstop production. The metal is then accumulated so that, during a splicing operation, the accumulator rollers can descend to provide a continuous flow of metal throughout the line. The metal is cleaned at temperatures of 120°F to 160°F, brushed, and rinsed to remove dirt, mill scale, grease and rust before coating begins. The metal is then treated for corrosion protection and for proper coating adhesion with various pretreatments, depending on the type of metal being coated and the type of coatings applied.

The first coat or primecoat may be applied on one or both sides of the metal by a set of three or more power-driven rollers. The pick-up roll, partially immersed in the coating, transfers the coating to the applicator roll. The metal is coated as it passes between the applicator roll and the large back-up roll. The metal is typically reverse roll coated. Exhibit 4-3, following Exhibit 4-2, is a schematic of a typical roll coater. A third roll, called a "doctor" roll, may be used to control film thickness when applying a high viscosity coating, by making contact with the pick-up roll.

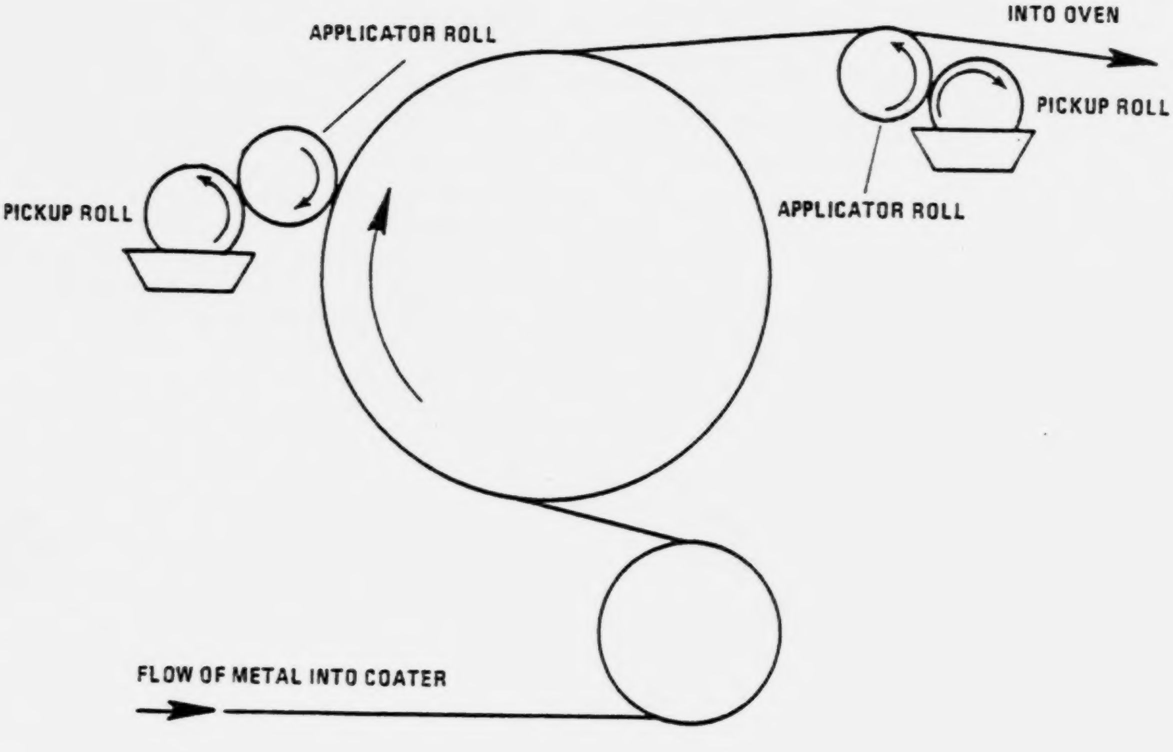
EXHIBIT 4-2

U.S. Environmental Protection Agency
DIAGRAM OF A COIL COATING LINE


UNCOILING METAL
SPLICER
ACCUMULATOR
METAL CLEANING
PRETREATMENT
PRIME COATER
PRIME OVEN
PRIME QUENCH
TOPCOAT COATER
TOPCOAT OVEN
TOPCOAT QUENCH
ACCUMULATOR
SHEAR
RECOILING METAL

Source: Control of Volatile Organic Emissions from Existing Stationary Sources-Volume II; Surface Coatings of Cans, Coils, Paper, Fabrics, Automobiles and Light Duty Trucks (EPA, 405/2-77-008, May 1977).

EXHIBIT 4-3
U.S. Environmental Protection Agency
TYPICAL REVERSE ROLL COATER


INTO OVEN
APPLICATOR ROLL
PICKUP ROLL
APPLICATOR ROLL
PICKUP ROLL
FLOW OF METAL INTO COATER

Source: Control of Volatile Organic Emissions from Existing Stationary Sources-Volume II; Surface Coatings of Cans, Coils, Paper, Fabrics, Automobiles and Light Duty Trucks (EPA, 405/2-77-008, May 1977).

The applied coating is usually dried or baked in a continuous, catenary or flotation or a double-pass oven that is multizone and high production. The temperatures of the preheat, drying or baking zones may range from 100°F to 1000°F depending on the type and film thickness of coating used and the type of metal being coated. The flow rates of the ovens' exhausts may vary from approximately 4,000 scfm to 26,000 scfm. Many of these ovens are designed for operation at 25 percent of the room-temperature lower explosive level when coating at rated solvent input. As the metal exits the oven, it is cooled in a quench chamber by either a spray of water or a blast of air followed by water cooling.

A second coat or topcoat may be applied and cured in a manner similar to the primecoat. The topcoat oven, however, is usually longer than the primecoat oven and contains more zones.

Another method of applying a primecoat on aluminum coils or a single coat on steel coils is to electrodeposit a waterborne coating to either one or both sides of the coil. The coil enters a V-shaped electrocoating bath that contains a roll on the bottom. As the metal goes around the roll, electrodes on each side can be activated and permit the coagulation of the paint particles on either one or both surfaces of the coil. The coated coil is then rinsed and wiped by squeeges to remove the water and excess paint particles. For steel coils, the electrodeposited coating must be baked in an oven. For aluminum coils, however, the primecoat is stable enough to go over rolls immediately to the topcoat coater without destroying the finish, and then be baked as a two-coat system.

After cooling, the coated metal passes through another accumulator, is sheared at the spliced section, usually waxed and finally recoiled. The accumulator rolls rise during the shearing process, collecting the coated metal to ensure continuous production.

Organic vapors are emitted in three areas of a coil coating line: the areas where the coating is applied, the oven and the quench area. The oven emits approximately 90 percent of the organic vapors and a majority of the other pollutants. Of the remaining 10 percent of hydrocarbons emitted, approximately 8 percent are emitted from the coater area and approximately 2 percent are emitted from the quench area.

4.2.3 Commercial Aspects of the Business

Coil coating was first practiced in the 1930s as a technique to coat metal for venetian blinds. As the technical, operating and economic advantages became apparent, the industry experienced remarkable growth. Since 1962, for example, estimated shipments have shown an average annual growth rate of some 16.5 percent. By 1977, as shown in Exhibit 4-4, on the following page, more than four million tons of aluminum and steel were coated using this method.

In terms of dollars, the four million tons of coated coil produced in the U.S. in 1977 represented a total product value of some $3.5 billion. Other pertinent indicators of the scale of this business include the following:

- Approximately 13 billion square feet of coated coil were produced.
- Organic coatings of several types currently utilized by the coil coaters in North America represent 19 million gallons. These, coupled with various types of film laminates, represent a total estimated value of $140 million in coatings.
- Chemical pretreatment for coil coaters is estimated at a value of $10 million.
- It requires approximately 12.8 billion cubic feet of natural gas and 4.1 million gallons of propane to cure these coatings. To coat the equivalent metal by "post painting" would require approximately five times this amount of energy.
- Today, there are 182 coil coating lines in North America, ranging in maximum coil width capacity from 2 to 60 inches and capable of running at maximum speed from 100 to 700 feet per minute.
- If all these lines were running at full capacity, it is estimated that they could coat more than 20 billion square feet of metal per year.

4.2.4 Approved Control Technologies

Per the Environmental Protection Agency Guidelines (EPA 905/2-78-001 April, 1978) in Article XX.9204, subpart (d)(2), the emission limit shall be achieved by:

- The application of low solvent content coating technology; or

EXHIBIT 4-4
Environmental Protection Agency
ESTIMATED TONNAGE OF METAL COATED IN THE
U.S. IN 1977 WITH COIL COATING TECHNIQUES

Market	Steel Shipments (tons)	Aluminum Shipments (tons)
Building products	1,100,000	610,000
Transportation	1,400,000	100,000
Appliances	140,000	25,000
Containers, packaging	80,000	200,000
Furniture, fixtures and equipment	110,000	15,000
Other uses	220,000	50,000
	3,050,000	1,000,000

Source: National Coil Coaters Association statistics.

- Incineration, provided that 90 percent of the nonmethane volatile organic compounds (VOC measured as total combustible carbon) which enter the incinerator are oxidized to carbon dioxide and water; or

- A system demonstrated to have control efficiency equivalent to or greater than provided under the preceding paragraphs. . .and approved by the Director.

4.2.5 Estimated Capital and Operating Costs to Control VOC Emissions

Estimates of capital and operating costs to control VOC emissions from coil coating operations were prepared by Springborn Laboratories, Inc., for the Environmental Protection Agency (Contract No. 68-02-2075, August 23, 1977). These estimates are discussed in this section.

The model chosen handles material 40 inches wide and coats at a speed of 300 feet per minute. This yields a yearly production of 204 million square feet when operated for 4,000 hours per year. The material usage is 344,630 gallons of paint and 34,460 gallons of solvent per year.

Case I	The base case with no controls for emissions; shows the cost of a new line using conventional enamel coating which does not meet RACT
Case II	The use of waterborne coating materials with no additional treatment of emissions
Case III	The base case with a thermal incinerator on each of the primecoat and topcoat ovens. Due to the relation of the coating applicator to the curing oven, the oven exhausts are assumed to be 90 percent of total emissions. The incinerator is figured with primary heat exchange to minimize the fuel costs and operates at an average 90 percent efficiency.

Emission control costs for each of the cases studied are summarized in Exhibit 4-5, on the following page. As indicated, additional capital costs to install emission control systems range from $50,000 to $254,000 over the base case capital cost depending on the alternative selected. Operating costs range from $8,000 to $75,000 more than the base case, or 0.3 percent to 2.5 percent increased cost per unit. Costs per ton of solvent range from $11 to $112.

EXHIBIT 4-5
U.S. Environmental Protection Agency
SUMMARY OF EMISSION CONTROL COSTS

Output 204,000,000 SF/yr.
(18,950,000 sq. meters)
4,000 hours/year

	Case	Total Investment $	Increase over Base Case $	Total Annual Cost $	Increased Annual Cost over Base Case $	Cost/Unit 1000 SF (1000 SM) $	Increased Cost Per 1000 SF over Base $	Increased Cost Per 1000 SF over Base %	Tons (Metric Tons) Solvent Emitted/Yr.	Decreased Emission over Base (Metric Tons)	Emission Reduction %	Cost/Ton (Metric Ton) To Remove Solvent $
I	Base Case - solvent-borne primecoat & topcoat	3,300,000	-	2,977,400	-	14.59 (157.05)	-	-	832.3 (755)	-	-	
II	Waterborne primecoat & topcoat	3,350,000	50,000	2,985,800	8,400	14.64 (157.58)	0.05	0.3	98.9 (89.9)	733.4 (665.1)	88	11.45 (12.63)
III	Base Case with thermal incinerators on ovens; primary heat recovery	3,554,260	254,260	3,052,860	75,460	14.96 (161.03)	0.37	2.5	158.1 (143.5)	674.2 (611.5)	81	111.93 (123.40)

Source: Booz, Allen & Hamilton Inc.

4.3 COIL COATING OPERATIONS IN THE STATE OF MICHIGAN

At present, there are four coil coating operations in Michigan. Details pertinent to these operations are shown in Exhibit 4-6, on the following page. It must be noted that much of the data and information shown in the exhibit was provided by the companies themselves and has not been validated.

Clearly, only Alsar will be required to install an emission control system to achieve RACT standards. However, this firm has indicated that there is some question as to their continued commercial viability even without the requirement to install an emission control system. However, if they decide to remain in the business and build a new coating line, it may be comparable to the plant model size previously described.

EXHIBIT 4-6

U.S. Environmental Protection Agency

COIL COATING OPERATIONS IN MICHIGAN

Company	Plant Location	No. of Coil Coating Lines	Type of Coatings	Emission Control Equipment	Comment
Alsar, Inc.	Southfield, MI	1	Solvent	None	Plant operates erratically
Bendix Modern Materials Corp.	Detroit, MI	2	Waterborne	Incinerator	Currently meeting RACT
Clark Brothers		1	Solvent	Incinerator	Within RACT
Wolverine Aluminum Corp.	Lincoln Park, MI	4	Solvent	Incinerator	Tested at 99% efficiency

Source: Booz, Allen & Hamilton Inc.

4.4 DIRECT ECONOMIC IMPLICATIONS

As previously indicated, application of RACT standards to the coil coating business in Michigan will have little or no economic impact. In fact, of the four identified coil coating operations in Michigan, only one would be required to add any type of emission control procedure.

This firm, Alsar Incorporated, currently operates a single coil coating line--primarily for captive aluminum requirements. The line is said to be noncompetitive in today's environment; however, Alsar is considering several options:

- Switch to a waterborne system
  - Have not yet found a satisfactory system
  - Are working with suppliers
- Install a retrofit thermal incinerator with heat recovery
- Shut down existing coaters
  - Purchase coated metal
  - Install new line with incinerator.

Under the most costly option, that of installing a new line comparable in size to the model plant, Alsar's additional capital cost to achieve RACT standards would be about $250,000 above the base case, if they were to build a unit similar to the Case III model discussed above. Additional annualized costs would be about $75,000 or 2.5 percent higher than the base case.

* * * *

Exhibit 4-7, on the following page, summarizes the findings presented in this chapter.

EXHIBIT 4-7
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR COIL COATING FACILITIES IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	There are four coil coating facilities potentially affected by the coil coating RACT guideline in Michigan. Three firms currently meet RACT emission limitations
Current industry technology trends	Due to the pressures of energy availability as well as environmental protection, most firms have or are installing regenerative-type incinerators
1977 VOC emissions (actual)	400 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Regenerative thermal incineration
Assumed method of control to most RACT guidelines	Regenerative thermal incineration

Affected Areas in Meeting RACT	Discussion
Capital Investment (statewide)	$250,000 incremental capital required by one firm if they were to install controls on a new processing line
Annualized Cost (statewide)	$75,000 (approximately 0.3 percent of industry's 1977 statewide value of shipments)
Energy	Small increased fuel consumption for regenerative incineration
Productivity	No major impact
Employment	No major impact
Market structure	The captive coil coating operation not meeting the RACT limitation may opt to purchase coated material in lieu of investing significant capital requirements
RACT timing requirements (1982)	Since most coil coating facilities in Michigan meet the RACT limitations, timing requirements should be met
Problem area	Low solvent coating technology is currently inadequate to meet product requirements
VOC emission after control	150 tons per year (37 percent of 1977 VOC emission level)
Cost effectiveness of control	$300 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Springborn Laboratories Inc.
EPA contract No. 68-02-2075, August 23, 1977

U.S. Environmental Protection Agency, Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II. Surface Coating of Cans, Coils, Paper, Fabrics, Automobiles and Light Duty Trucks. EPA-450/2-77-008, May, 1977

Private conversations at the following:

National Coil Coaters Association

Alsar Inc., Southfield, Michigan

Wolverine Aluminum Corp., Lincoln Park, Michigan

5.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING PAPER IN THE STATE OF MICHIGAN

5.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING PAPER IN THE STATE OF MICHIGAN

This chapter presents a detailed analysis of the impact of implementing RACT for plants in the State of Michigan which are engaged in the surface coating of paper. This is meant to include protective or decorative coatings put on paper, pressure-sensitive tapes regardless of substrate, related web coating processes on plastic film and decorative coatings on metal foil, but does not include conventional printing processes which apply inks. The chapter is divided into five sections:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines; previous studies of paper coating; interviews with paper coaters, coating equipment and materials manufacturers; and a review of pertinent published literature.

5.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impacts

for plants engaged in the surface coating of paper. The quality of these estimates is discussed in the last part of this section.

5.1.1 Industry Statistics

Paper coating is practiced in a number of industries. Among products that are coated using organic solvents are: adhesive tapes; adhesive labels; decorated, coated and glazed paper; book covers; office copier paper; carbon paper; typewriter ribbons; photographic film; paper cartons; and paper drums. The firms coating paper are classified in a number of groupings in the U.S. Department of Commerce's Standard Industrial Classification system. The major coaters may be found in the following 16 SIC groups:

SIC	Description
2611	Pulp mills
2621	Paper mills, except building paper mills
2631	Paperboard mills
2641	Paper coating and glazing
2643	Bags, except textile bags
2645	Diecut paper and paperboard and cardboard
2649	Paper converting, n.e.c.
2651	Folding paperboard boxes
3291	Abrasive products
3292	Asbestos products
3293	Gaskets, packing and sealing devices
3497	Metal foil and leaf
3679	Electronic components, n.e.c.
3842	Orthopedic, prothetic and surgical appliances and supplies
3861	Photographic equipment and supplies
3955	Carbon paper and inked ribbons

This list does not include plants listed in the SIC category 2700 (Printing, Publishing and Allied Industries) where paper coating other than printing may also be a part of the overall processing of the printed product.

Statistics concerning these industries were obtained from a number of sources. All data where possible were converted to the base year 1977 for the state using scaling factors developed from U.S. Department of Commerce data as presented in County Business Patterns. The primary sources of economic data were the 1972 Census of Manufactures and 1976 Annual Survey of Manufactures. Industry oriented annuals such as Lockwoods' Directory and Davidson's BlueBook and the Thomas Register of American Manufacturers were used to identify some of the individual companies engaged in paper conversion (i.e., coating of paper in roll form for sale to other manufacturers) and to identify other paper coating firms.

The majority of VOC emissions from paper coating result from coating done by firms in SIC grouping 2641, paper coating and glazing. However, because of the total number of firms which may coat paper as part of their normal business, we have included in our industry statistics the data for all firms grouped in the list above.

We have relied heavily on the Michigan emission inventory to identify the firms expected to be affected by the proposed paper coating regulations. However, this inventory has been found to be deficient in terms of number of firms listed and type and volume of emissions. This deficiency has been filled, to a degree, by interviews with several large coaters in the state and with other industry sources.

5.1.2 VOC Emissions

The Michigan emission inventory was used as a basis for estimation of the total VOC emissions to be expected in the state. Though the inventory may be incomplete, it is expected to account for the majority of the emissions in the state and for large single sources. The inventory, however, may omit a number of small firms that have low total emissions but could be affected by the RACT guideline.

5.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions from sources included in the paper coating category are described in Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-77-008). The feasibility of applying the various control methods to paper coating discussed in this document was reviewed with coating firms, coating suppliers, coating equipment manufacturers and industry associations. These methods include both coating reformulation and the use of control devices, such as incinerators and carbon adsorbers.

Because of the wide variety of coating processes and coating materials in use, most methods of control will find some applicability. The percentage of emissions to be controlled by reformulation and by control devices was estimated based on a review of the literature and on information obtained from the interviews described above.

5.1.4 Cost of Control and Estimated Reduction of VOC Emissions

The overall costs of control of VOC emissions in accord with the proposed regulations were determined from:

- Estimated current emissions
- Estimated type of control to be used--coating reformulation or control device
- A development of capital, operating and energy requirements for reformulation or use of a control device for an average-sized model installation
- Extrapolation of the model plant costs to an industry total based on current emissions.

Model plant costs were primarily based on information provided from:

- Control of Volatile Organic Emissions from Existing Stationary Sources, Volume I (EPA-450/2-76-028)
- Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories.

Additional cost data were supplied by equipment and material suppliers and published literature sources. Major coaters were consulted to determine industry views on acceptable control methods and, in some cases, to provide direct estimates of their projected control costs and experience in control equipment installations.

Both coaters and equipment manufacturers were consulted to obtain their opinions on the likelihood of meeting proposed RACT compliance schedules. In all interviews made, proposed schedules appeared to be unrealistic; therefore, these firms were asked to estimate their likely costs (in 1977 dollars) based on the assumption that equipment will be available for their selected control option.

5.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements to implement RACT, assessing the feasibility of instituting RACT controls in terms of capital and equipment availability, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Michigan.

5.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of paper in Michigan. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that are published for the base year), "B" indicates data that were extrapolated from hard data and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 5-1, on the following page, rates each study output listed and the overall quality of the data.

It should be noted that the economic estimates presented in this report are based primarily on the State of Michigan Department of Natural Resources emission inventory which is not believed to be complete in terms of number of firms affected by this portion of the regulation and their emissions. However, it is considered that the largest emitters are included and that the emissions inventoried include 80 percent or more of the total emissions in the paper coating category.

EXHIBIT 5-1
U.S. Environmental Protection Agency
DATA QUALITY--SURFACE COATING OF PAPER

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		X	
Emissions	X		
Cost of emissions control		X	
Economic impact			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

5.2 INDUSTRY STATISTICS

Industry characteristics, statistics and trends for paper coating in Michigan are presented in this section. This information forms the basis for assessing the total impact of implementing RACT for control of VOC emissions in the state and for the effect upon individual firms. Though there are a number of firms which coat paper as a part of the manufacturing process, this discussion concentrates primarily on those firms whose only major activity is paper coating.

5.2.1 Size of the Industry

The Bureau of Census reports a total of about 397 firms in 16 SIC categories in Michigan where paper coating, as defined in proposed RACT guidelines, is the main business of the firm or may be a part of its manufacturing activity. The number of firms and other relevant statistics in each SIC grouping are summarized in Exhibit 5-2, on the following page.

Total value of shipments for these firms is estimated to be about $1.7 billion, with a total of about 22,990 employees. New capital expenditures are estimated to be about $137.4 million annually, based on the most recent (1976) Annual Survey of Manufactures.

The 22 firms in SIC category 2641, those expected to be most affected by the proposed regulations, have estimated shipments of $184 million, with a total of 2,300 employees.

The Michigan inventory, by contrast, lists a total of 27 plants expected to be covered under the paper coating RACT category and only six under SIC category 2641. Lockwood's 1977 directory of the paper industry lists 28 firms as paper converters with plants in Michigan.

5.2.2 Comparison of the Industry to the State Economy

A comparison of the value of shipments of plants in the SIC categories listed above with the state economy indicates that these plants represent about 2.8 percent of the total value of shipments in Michigan. The industry employs 2.0 percent of all manufacturing employees in Michigan, with a payroll equal to about 2.2 percent of the state total for all employees in manufacturing industries.

EXHIBIT 5-2

U.S. Environmental Protection Agency

1976 INDUSTRY STATISTICS--SURFACE COATING OF PAPER SIC GROUPS IN MICHIGAN

SIC Code	Description	Number of Plants	Total Number of Employees	Total Payroll ($1,000)	Estimated Value of Shipments ($1,000)	Estimated New Expenditures ($1,000)
2611	Pulp mills	1	170	a	22,000	4,000
2621	Paper mills, except building paper mills	20	6,500	102,500	610,000	54,300
2631	Paperboard mills	14	3,100	51,100	338,000	42,300
2641	Paper coating and glazing	22	2,300	30,700	184,000	5,200
2643	Bags, except textile bags	13	500	5,600	34,000	9,500
2645	Diecut paper and paperboard and cardboard	20	1,100	12,600	76,500	2,100
2649	Paper converting, n.e.c.	13	a	a	-	-
2651	Folding paperboard boxes	13	1,400	19,800	88,800	2,600
3291	Abrasive products	47	1,600	21,600	99,500	3,100
3292	Asbestos products	b	b	b	-	-
3293	Gaskets, packing and sealing devices	29	1,700	21,000	71,700	2,500
3497	Metal foil and leaf	117	2,500	25,100	92,600	2,800
3679	Electronic components, n.e.c.	38	640	5,400	19,800	800
3842	Orthopedic, prothetic and surgical appliances and supplies	32	1,170	10,700	43,100	1,500
3861	Photographic equipment and supplies	15	250	3,300	16,800	6,600
3955	Carbon paper and inked ribbons	3	60	a	4,200	100
Total		397	22,990	309,400	1,701,000	137,400

---

a. Not listed to protect proprietary information.

b. Not listed.

ource: Booz, Allen & Hamilton Inc.; 1976 Annual Survey of Manufactures, U.S. Department of Commerce.

5.2.3 Historical and Future Patterns of the Industry

The value of shipments in the industries expected to be affected by the proposed paper coating regulations, in general, exceed the growth rate of the economy. As summarized in Exhibit 5-3, on the following page, the value of shipments increased in every category between 1972 and 1976, with an average annual growth rate of about 12.1 percent over the period. Compared to an average inflationary rate of 6 to 8 percent, this is equivalent to a real growth rate of 4 to 6 percent. In some individual categories, growth rates were even greater. Paper production increased by an uncorrected average annual growth rate of 16.5 percent; metal and foil by 16 percent; paper coating and glazing by about 12 percent, only slightly less than the average.

It is expected that the growth rate will increase at these rates for the near future.

EXHIBIT 5-3
U.S. Environmental Protection Agency
HISTORICAL TRENDS IN VALUE OF SHIPMENTS OF
U.S. PLANTS ENGAGED IN PAPER COATING ($ millions)

SIC Code	1972	1973	1974	1975	1976
26[illegible]					
26[illegible]1	710	849	1,525	1,630	2,055
26[illegible]1	6,385	7,514	9,942	9,650	11,768
26[illegible]1	4,153	4,862	6,516	6,055	6,724
26[illegible]1	1,954	2,284	2,645	2,626	3,074
26[illegible]3	1,886	2,183	2,867	2,980	3,379
26[illegible]5	676	747	923	943	1,027
26[illegible]9	631	833	1,079	1,090	1,288
32[illegible]1	1,487	1,644	1,890	1,952	2,223
32[illegible]1	888	1,067	1,235	1,222	1,433
32[illegible]2	763	823	963	900	988
34[illegible]3	665	723	835	843	1,020
36[illegible]7	702	753	973	1,065	1,267
38[illegible]9	3,060	3,430	3,210	3,450	4,120
38[illegible]2	1,450	1,620	1,800	2,090	2,240
39[illegible]1	5,624	6,435	7,490	7,627	8,844
[illegible]5	237	268	309	285	294
Total	31,271	36,035	42,400	44,408	51,744

Source: 1976 Annual Survey of Manufactures, U.S. Department of Commerce

5.3 TECHNICAL SITUATION IN THE INDUSTRY

This section presents a description of the principal processes used in the surface coating of paper and similar products proposed to be included under the RACT Surface Coating of Paper regulations. These products include a myriad of consumer and industry oriented items, such as pressure-sensitive tapes, adhesive labels, book covers, milk cartons, flexible packaging materials and photographic film. As indicated earlier, in Michigan alone, about 400 plants produce such products, which are probably coated by processes covered under this RACT category not including those grouped under publishing or printing. Also discussed are estimated VOC emissions for the state and extent of controls in current use.

5.3.1 General Coating Process Description

In organic solvent paper coating, resins are dissolved in an organic solvent mixture and this solution is applied to a web (continuous roll) of paper. As the coated web is dried, the solvent evaporates and the coating cures. An organic solvent has several advantages: it will dissolve organic resins that are not soluble in water, its components can be changed to control drying rate, and the coatings show superior water resistance and better mechanical properties than most types of waterborne coatings. In addition, a large variety of surface textures can be obtained using solvent coatings.

Most organic solvent-borne coating is done by paper converting companies that buy paper from the mills and apply coatings to produce a final product. The paper mills themselves sometimes apply coatings, but these are usually waterborne coatings consisting of a pigment (such as clay) and a binder (such as starch or casein). However, much additional coating is done by firms only as part of the manufacturing process. For instance, many printed items (e.g., periodical covers, playing cards and cartons) are printed first and then coated in the printing plant with a protective coating which can provide abrasion resistance, water resistance or decorative effects.

Nationwide emissions of organic solvents from paper coating have been estimated to be 0.56 million tons per year.[1] This estimate includes resin emissions from solventless polyethylene extrusion coatings applied to milk cartons and resin emissions from water emulsion coatings and from rubber adhesives used to glue paper bags and boxes. A lower estimate, based on solvent emissions from the type of coating operations found in SIC 2641, is 0.35 million tons per year. The true total emission rate, however, is probably closer to the 0.56 million tons per year value. This is slightly less than 3.0 percent of the estimate of 19 million tons per year of hydrocarbon emissions from all stationary sources previously reported by EPA.[2] Manufacturing of pressure sensitive tapes and labels, the largest single solvent emission source in SIC 2641, alone accounts for 0.29 million tons per year.

Solvent emissions from an individual coating facility will vary with the size and number of coating lines. A plant may have one or as many as 20 coating lines. Uncontrolled emissions from a single line may vary from 50 pounds per hour to 1,000 pounds per hour, depending on the line size. The amount of solvent emitted also depends on the number of hours the line operates each day.

Exhibit 5-4, on the following page, gives typical emission data from various paper coating applications.

5.3.2 Nature of Coating Materials Used

The formulations usually used in organic solvent-borne paper coatings may be divided into the following classes: film-forming materials, plasticizers, pigments and solvents. Dozens of organic solvents are used. The major ones are: toluene, xylene, methyl ethyl ketone, isopropyl alcohol, methanol, acetone and ethanol.

Although a single solvent is frequently used, often a solvent mixture is necessary to obtain the optimum drying rate. Too rapid drying results in bubbles and an "orange peel" effect in the coating; whereas, slow drying coatings require more time in the ovens or slower production rates. Variations in the solvent mixture also affect the solvent qualities of the mix.

---

1. T. W., Hughes, et al., Source Assessment: Prioritization of Air Pollution from Industrial Surface Coating Operations, Monsanto Research Corporation, Dayton, Ohio. Prepared for U.S. Environmental Protection Agency, Research Triangle Park, N.C., under Contract No. 68-02-1320 (Tech. 14) Publication No. 650/2-75-019a.

2. EPA 450/2-76-028, Op. Cit.

EXHIBIT 5-4

U.S. Environmental Protection Agency

EMISSION DATA FROM TYPICAL PAPER COATING PLANTS

Number of Coating Lines	Solvent Usage (lb./day)	Solvent Emissions (lb./day)	Control Efficiency (%)[a]	Control Device
2	10,000	10,000	-	None
5	15,000	15,000	-	None
8	9,000	9,000	-	None
2	1,200	1,200	-	None
10	24,000	950	96	Carbon adsorption
20	55,000	41,000	90	Carbon adsorption (not all lines controlled)
3	5,000	1,500	90	Carbon adsorption
3	21,000	840	96	Carbon adsorption
1	10,500	500	96	Afterburner

---

[a] Neglecting emissions that are not captured in the hooding system.

Source: Control of Volatile Organic Emissions from Existing Stationary Sources Volume II (EPA)-450/2-77-008

The main classes of film formers used in conventional paper coating are cellulose derivatives and vinyl resins. The most commonly used cellulose derivative, nitrocellulose has been used for paper coating decorative paper, book covers and similar items since the 1920s. It is relatively easy to formulate and handle, and it dries quickly, allowing lower oven temperatures than vinyl coatings. The most common vinyl resin is the copolymer of vinyl chloride and vinyl acetate. These vinyl copolymers are superior to nitrocellulose in toughness, flexibility and abrasion resistance. They also show good resistance to acids, alkyds, alcohols and greases. Vinyl coatings tend to retain solvent, however, so that comparatively high temperatures are needed. In general, nitrocellulose is most applicable to the decorative paper field, whereas vinyl copolymers are used for functional papers, such as some packaging materials.

In the production of pressure-sensitive tapes and labels, adhesives and silicone release agents are applied using an organic solvent carrier. The adhesive layer is usually natural or synthetic rubber, acrylic or silicone. Because of their low cost, natural and synthetic rubber compounds are the main film formers used for adhesives in pressure-sensitive tapes and labels, although acrylic and silicone adhesives offer performance advantages for certain applications. In most cases tapes and labels also involve the use of release agents applied to a label carrier or the backside of tape to allow release. The agents are usually silicone compounds applied in a dilute solvent solution.

5.3.3 Coating Process Most Commonly Used

Exhibit 5-5, on the following page, shows a typical paper coating line. Components include an unwind roll, a coating applicator (knife, reverse roll or gravure), an oven, various tension and chill rolls and a rewind roll. The unwind, rewind and tension rolls display various degrees of complexity, depending on the design of the line.

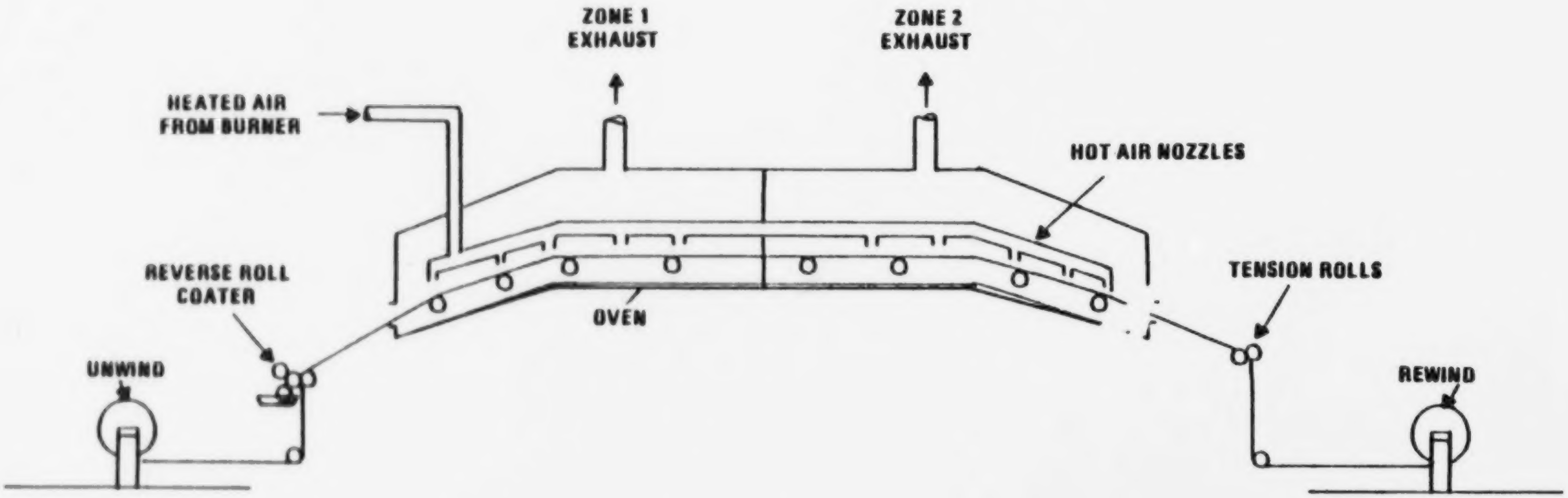
The coating applicator and the oven are the main areas of organic emission in the paper coating facility.

Coatings may be applied to paper in several ways. The main application devices are knives, reverse rollers or rotogravure devices.

A knife coater (Exhibit 5-6, following Exhibit 5-5) consists of a blade that scrapes off excess coating on the paper. The position of the knife (relative to the paper surface) can be adjusted to control the thickness of the coating. The knife coater is simply constructed and easy to clean.

EXHIBIT 5-5
U.S. Environmental Protection Agency

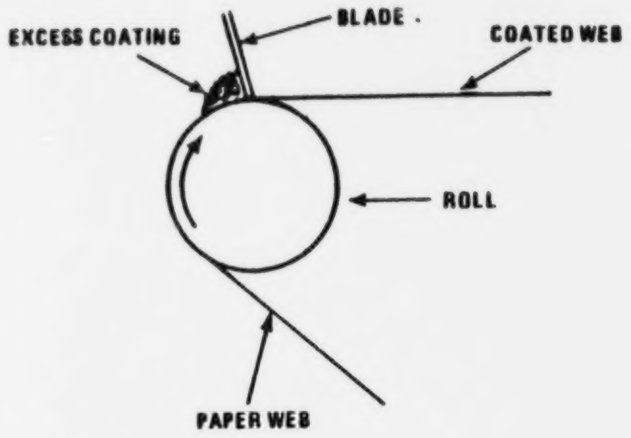
TYPICAL PAPER COATING LINE


ZONE 1 EXHAUST
ZONE 2 EXHAUST
HEATED AIR FROM BURNER
HOT AIR NOZZLES
REVERSE ROLL COATER
TENSION ROLLS
OVEN
UNWIND
REWIND

Source: Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II; Surface Coating of Cans, Coils, Paper, Fabrics Autombiles, and Light-Duty Trucks, EPA 450/2-77-008, May, 1977

EXHIBIT 5- 6
U.S. Environmental Protection Agency

KNIFE COATER


EXCESS COATING
BLADE
COATED WEB
ROLL
PAPER WEB

Source: *Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II; Surface Coating of Cans, Coils, Paper, Fabrics Autombiles, and Light-Duty Trucks*, EPA 450/2-77-008, May, 1977

The reverse roll coater (Exhibit 5-7, on the following page) applies a constant thickness of coating to the paper web, usually by means of three rolls, each rotating in the same direction. A transfer roll picks up the coating solution from a trough and transfers it to a coating roll. (Sometimes there is no transfer roll and the coating is pumped directly onto a coating roll.) A "doctor roll" removes excess material from the coating roll. The gap between the doctor roll and the coating roll determines the thickness of the coating. The web is supported by a rubber backing roll where the coating roll contacts the paper. The coating roll turns in a direction opposite to that of the paper, hence the name "reverse roll." This reverse direction of the coating roll reduces striations in the coating that can form if the coating roll is turned in the same direction as the paper web.

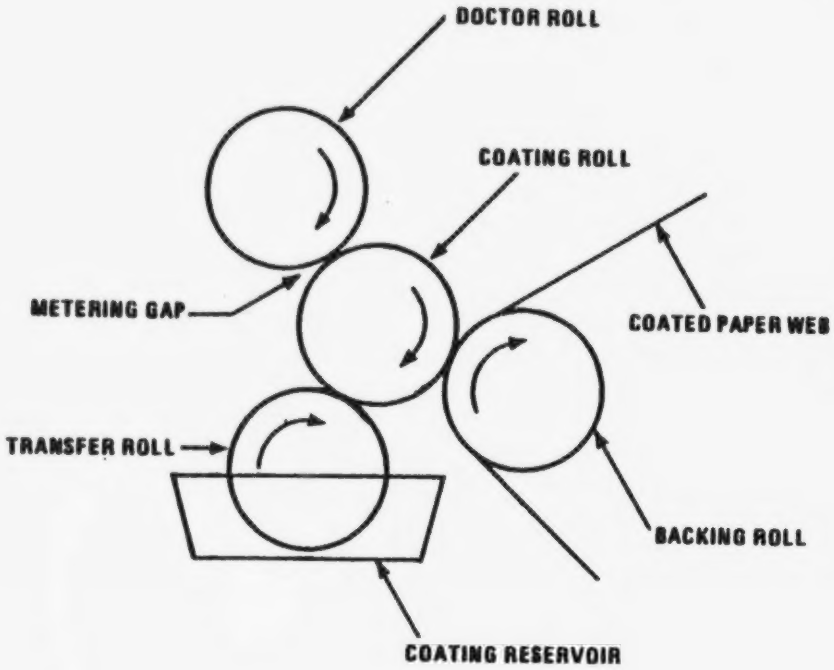
Knife coaters can apply solutions of much higher viscosity than roll coaters and thus less solvent is emitted per pound of coating applied. Knife coaters handle coatings with viscosity up to 10,000 centipoise (cp). Reverse roll coaters operate best in a much more dilute range, where viscosity is 300 to 1,500 cp. Roll coaters, however, can usually operate at higher speeds and show less tendency to break the paper.

Rotogravure, another type of application method used by paper coaters, is usually considered a printing operation. With it, the image area on the coating or rotogravure roll is recessed relative to the nonimage area. The coating is picked up in the recessed area of the roll and transferred directly to the substrate. The gravure printer can print patterns or a solid sheet of color on a paper web. Rotogravure can also be used to apply materials, such as silicone release coatings for pressure-sensitive tapes and labels. Because of the similarities, the regulation is applicable to gravure as well as knife and roll coating.

Most solvent emissions from coating paper come from the dryer or oven. Ovens range from 20 feet to 200 feet in length and may be divided into two to five temperature zones. The first zone, where the coated paper enters the oven, is usually at a low temperature (110°F). Solvent emissions are highest in this zone. Other zones have progressively higher temperatures that cure the coating after most of the solvent has evaporated. The typical curing temperature is 250°F, although in some ovens temperatures of 400°F are reached. This is generally the maximum because higher temperatures can damage the paper. Exhaust streams from oven zones may be discharged independently to the atmosphere or into a common exhaust and sent to some type of air pollution control device. The average exhaust temperature is about 200°F.

EXHIBIT 5-7
U.S. Environmental Protection Agency

REVERSE ROLL COATER


DOCTOR ROLL
COATING ROLL
METERING GAP
COATED PAPER WEB
TRANSFER ROLL
BACKING ROLL
COATING RESERVOIR

Source: Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II; Suface Coating of Cans, Coils, Paper, Fabrics, Autombiles, and Light-Duty Trucks, EPA 450/2-77-008, May, 1977

However, in some coatings, such as in the manufacture of photographic films or thermographic recording paper, the heat sensitivity of the films requires that temperatures considerably lower than this must be used. Exhaust temperatures may be as low as 100°F. Thus, much larger relative volumes of air must be used than is possible with common paper coating.

5.3.3 Current VOC Emissions

This section presents the estimated VOC emissions from paper coating operations in Michigan for the year 1977, based on the Michigan Department of Natural Resources inventory of air pollution sources. A summary of this inventory and applicable emissions for the paper coating RACT category is presented in Exhibit 5-8, on the following page. Plants listed are believed to represent the major single sources of emissions and in total represent the major portion of paper coating emissions in the state.

5.3.4 RACT Guidelines

The RACT guidelines for control of VOC emissions from the surface coating of paper require that emission discharges of VOCs be limited to 2.9 pounds per gallon of coating material delivered to the coating applicator.

The recommended methods of achieving this requirement are:

- The application of low solvent content coatings; or

- Incineration, provided that 90 percent of the nonmethane VOCs (measured as combustible carbon) which enter the incinerator are oxidized to carbon dioxide and water; or

- A system demonstrated to have control efficiency equivalent to or greater than provided by either of the above methods.

In the following section are discussed several methods of low solvent and solventless systems, which have been demonstrated to be applicable to some paper coating products, and the two principal add-on systems, incineration and carbon adsorption, generally used for emission control. This information has been extracted principally from the previously cited EPA report, Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II, which should be consulted for a more thorough discussion. In some instances, additional comment was obtained from coaters, coating material suppliers and control equipment manufacturers.

EXHIBIT 5-8 (1)

U.S. Environmental Protection Agency

COMPANY ESTIMATES OF PAPER COATING EMISSIONS
AS REPORTED TO MICHIGAN DEPARTMENT OF NATURAL RESOURCES

SIC Code	Company Name, Location	Employees	Total Reported Emissions (tons/year)	Emissions Estimated As Applicable Under Paper Coating Category (tons/year)
2645	Aero Detroit, Inc. Oak Park	393	2	2
2641	Armak Company, Tape Division Marysville	300	9,180	9,180
2631	Brown Company Kalamazoo	1,709	215	215
2621	Brown Company Parchment	1,321	1,836	1,824
2650	Cadillac Products Warren	(a)	75	0
2651	C&S Carton, Inc. Marshall	(a)	8	6
2631	Consolidated Packaging Corp. Monroe	230	27	27
2655	Continental Can Co. Midland	120	130	84
2655	Continental Can Co. Three Rivers	(a)	34	34
2650	Display Pack, Inc. Grand Rapids	40	12	0
2655	Grief Brothers Corp. Wyandotte	100	19	0
2641	Graphic Controls Corp. Alpena	20	1,414	1,414

EXHIBIT 5-8(2)
U.S. Environmental Protection Agency

SIC Code	Company Name, Location	Employees	Total Reported Emissions (tons/year)	Emissions Estimated As Applicable Under Paper Coating Category (tons/year)
2641	Hackett Corporation Howell	(a)	2	0
2621	James River Rochester Paper Co. Rochester	85	2,557	2,557
2621	Kimberly Clark Paper Mill Munsing	457	32	32
2641	Label Technique, Inc. Sturgis	(a)	2	2
2621	Mead Paper Co. Excanaba	1,000	7	6
2631	Menasha Corp. Otsego	235	145	145
2651	Muskegon Paper Box Co. Muskegon	(a)	9	9
2651	Packaging Corp. of America Grand Rapids	(a)	52	0
2653	Packaging Corp. of America Grandville	130	6	0
2651	Packaging Corp. of America Portage	(a)	5	2
2651	St. Regis Paper Co. Battle Creek	210	1,727	0
2641	Simplex Industries Constantine	(a)	296	296

EXHIBIT 5-8(3)

SIC Code	Company Name, Location	Employees	Total Reported Emissions (tons/year)	Emissions Estimated As Applicable Under Paper Coating Category (tons/year)
2611	Simpson Paper Co. Vicksburg	334	18	17
2631	Time Container Corp. Monroe	205	11	11
2631	Union Camp Corp. Monroe	381	102	102
	Total		17,923	13,137

---

a. Not reported.

Source: Michigan Department of Natural Resources Inventory

5.3.5 Low Solvent and Solventless Coatings

In Exhibit 5-9, on the following page, are listed several types of coating materials, which have found utility in paper coating, and an estimate of expected solvent reduction.

5.3.5.1 Waterborne Coatings

Waterborne coatings have long been used in coating paper to improve printability and gloss. The most widely used types of waterborne coatings consist of an inorganic pigment and nonvolatile adhesive. These waterborne coatings are useful but cannot compete with organic solvent coatings in properties such as weather, scuff and chemical resistance. Newer waterborne coatings have been developed in which a synthetic insoluble polymer is carried in water as a colloidal dispersion or an emulsion. This is a two-phase system in which water is the continuous phase and the polymer resin is the dispersed phase. When the water is evaporated and the coating cured, the polymer forms a film that has properties similar to those obtained from organic-solvent-based coatings.

5.3.5.2 Plastisols and Organisols

Plastisols are a colloidal dispersion of synthetic resin in a plasticizer. When the plasticizer is heated, the resin particles are solvated by the plasticizer so that they fuse together to form a continuous film. Plastisols usually contain little or no solvent, but sometimes the addition of a filler or pigment will change the viscosity so that organic solvents must be added to obtain desirable flow characteristics. When the volatile content of a plastisol exceeds 5 percent of the total weight, it is referred to as an organisol.

Paper is coated with plastisols to make such products as artificial leather goods, book covers, carbon paper and components of automobile interiors. Plastisols may be applied by a variety of means, but the most common method is probably reverse roll coating. One advantage of plastisols is that they can be applied in layers up to 1/8 thick. This avoids the necessity of multiple passes through a coating machine.

Although organic solvents are not evaporated from plastisols, some of the plasticizer may volatilize in the oven. This plasticizer will condense when emitted from the exhaust stack to form a visible emission.

EXHIBIT 5-9
U.S. Environmental Protection Agency
ACHIEVABLE SOLVENT REDUCTIONS USING LOW SOLVENT COATINGS IN PAPER COATING INDUSTRY

Type of Low Solvent-Coating	Reduction Achievable (%)[a]
Waterborne coatings	80-99
Plastisols	95-99
Hot melts	99+
Extrusion coatings	99+
Pressure-sensitive adhesives	
Waterborne	80-99
Hot melts	99
Prepolymer	99
Silicone release agents	
100 percent nonvolatile coatings	99+
Waterborne emulsions	80-99

---

a. Based on comparison with a conventional coating containing 35 percent solids by volume and 65 percent organic solvent by volume.

Source: EPA 450/2-76-028, op. cit.

5.3.5.3 Hot Melt Coatings

Hot melt coatings contain no solvent; the polymer resins are applied in a molten state to the paper surfaces. All the materials deposited on the paper remain as part of the coating. Because the hot melt cools to a solid coating soon after it is applied, a drying oven is not needed to evaporate solvent or to cure the coating. Energy that would have been used to heat an oven and to heat makeup air to replace oven exhaust is therefore saved. Considerable floor space is also saved when an oven is not used. In addition, the paper line speed can be increased because the hot melt coating cools faster than a solvent coating can dry.

One disadvantage with hot melt coatings is that materials that char or burn when heated cannot be applied by hot melt. Other materials will slowly degrade when they are held at the necessary elevated temperatures.

Hot melts may be applied by heated gravure or roll coaters and are usually applied at temperatures from 150°F to 450°F. The materials with a lower melting point are generally waxy materials with resins added to increase gloss and hardness. The materials with a higher melting point form films that have superior scuff resistance, transparency and gloss. These coatings form excellent decorative finishes. One particular advantage of hot melts is that a smooth finish can be applied over a rough textured paper. This is possible because the hot melt does not penetrate into the pores of the paper.

5.3.5.4 Extrusion Coatings

A type of hot melt coating, plastic extrusion coating is a solventless system in which a molten thermoplastic sheet is discharged from a slotted dye onto a substrate of paper, paperboard or snythetic material. The moving substrate and molten plastic are combined in a nip between a rubber roll and a chill roll. A screw-type extruder extrudes the coating at a temperature sometimes as high as 600°F. Low and medium density polyethylene are used for extrusion coating more than any other types of resins.

5.3.5.5 Pressure-Sensitive Adhesive Coatings

In 1974, sales of pressure-sensitive adhesives in the United States exceeded $1 billion, and the growth rate was about 15 percent per year. Products using pressure-sensitive adhesives include tapes and labels, vinyl wall coverings and floor tiles. Nationwide, organic solvent emissions from pressure sensitive tape and label manufacture have been estimated to be 580 million pounds per year.

Waterborne adhesives have the advantage that they can be applied with conventional coating equipment. Waterborne emulsions, which can be applied less expensively than can solvent-borne rubber-based adhesives, are already in use for pressure-sensitive labels. A problem with waterborne adhesives is that they tend to cause the paper substrate to curl and wrinkle.

Pressure-sensitive hot melts currently being marketed consist mostly of styrene-butadiene rubber block copolymers. Some acrylic resins are used, but these are more expensive. The capital expense of hot melt coating equipment is a problem for paper coaters that have already invested heavily in conventional solvent coating equipment.

Pre-polymer adhesive coatings are applied as a liquid composed of monomers containing no solvent. The monomers are polymerized by either heat or radiation. These prepolymer systems show promise, but they are presently in a developmental stage only.

5.3.5.6 Silicone Release Coatings

Silicone release coatings, usually solvent-borne, are sometimes used for pressure-sensitive, adhesive-coated products. Two low-solvent alternatives are currently on the market. The first is a 100 percent nonvolatile coating which is usually heatcured, but may be radiation cured. This is a prepolymer coating which is applied as a liquid monomer that is crosslinked by the curing process to form a solid film. The second system is water emulsion coatings which is lower in cost than the prepolymer coating. However, because of wrinkling and other application problems the waterborne coating may be of limited value.

Some silicone coating materials which are under development use single solvent systems that can be readily recovered by carbon adsorption. Current coatings are troublesome since some silicone is carried into the adsorber where it clogs the carbon pores to reduce adsorption efficiency.

5.3.6 Incineration

Catalytic and direct thermal incineration processes convert hydrocarbons to carbon dioxide and water at high temperatures. Incineration is widely accepted as a reliable means of reducing hydrocarbon emissions by 90 percent or more.

Generally, the major disadvantage of this approach is the increased energy required to raise the exhaust gas temperatures above 1,200°F for direct incineration and 700°F for catalytic incineration. Natural gas is the most commonly used fuel though fuel oils, propane or other fluid hydrocarbons can be employed. Fuel oil is not generally acceptable because of the sulfur oxides generated in combustion or possible catalyst poisoning in the oil. Another problem is the generation of nitrogen oxides in direct fired incinerators because of the exposure of air to high-temperature flames.

The increased energy consumption can, in some cases, be reduced or eliminated by heat exchange of the exhaust gases with fresh emissions (primary heat recovery) or by use of the hot incinerator exhaust gases in process applications (secondary heat recovery). Typical use of secondary heat recovery is for oven heat in drying or baking ovens. In fact, with efficient primary exchange and secondary heat recovery, total fuel consumption of an incinerator-oven system can be less than that for the oven before the incinerator is added. The heat required to sustain the system comes from the combustion of the volatile organic compounds in the exhausts.

Both catalytic and direct fired systems are capable of high heat recovery efficiency if several conditions occur:

- VOC concentrations are or can be increased to 8-10 percent or more of their LEL (lower explosion limit).
- Oven temperatures are sufficiently high to be able to use most of the sensible heat in the exhaust gases after primary heat exchange. Usually, temperatures above 140°F to 150°F can be sufficient to allow 85 percent or more overall heat recovery.
- Where catalytic incinerators are used, no compounds must be present in the gases treated which could poison or blind the catalyst.

In most paper coating operations, except for heat-sensitive products such as photographic paper and film, these conditions can be met. In other cases, 50-85 percent primary heat recovery can be attained and at least a portion of the incinerator exhaust heat can be used for in-plant energy requirements.

Paper coaters who use coating machinery for a multiplicity of processes have commented that catalytic incineration would probably not be used because of the possibility of catalyst poisoning. Direct fired incineration would be used.

5.3.7 Carbon Adsorption

Carbon adsorption has been used since the 1930s for collecting solvents emitted from paper coating operations. Most operational systems on paper coating lines were installed because they were profitable. Pollution control has usually been a minor concern. Carbon adsorption systems at existing paper coating plants range in size from 19,000 scfm to 60,000 scfm. Exhausts from several paper coating lines are often manifolded together to permit one carbon adsorption unit to serve several coating lines. Paper products that are now made on carbon-adsorption-controlled lines include pressure sensitive tape, office copier paper, and decorative paper.

Carbon adsorption is most adaptable to single solvent processes. Many coaters using carbon adsorption have reformulated their coatings so that only one solvent is required. Toluene, a widely used solvent for paper coating, is readily captured in carbon adsorption systems.

The greatest obstacle to the economical use of carbon adsorption is that, in some cases, reusing recovered solvents may be difficult. In many coating formulations, a mixture of several solvents is needed to attain the desired solvency and evaporation rates. Also if different coating lines within the plant use different solvents and are all ducted to one carbon adsorption system, then there may be difficulty reusing the collected solvent mixture. In some cases, such as in the preparation of photographic films or thermographic recording paper, extremely high purity solvents are necessary to maintain product performance and even distillation may be insufficient to produce the quality of recovered solvent needed. For most other coating formulations, distillation is adequate.

Separation of solvent mixtures by distillation is a well-established technology and several plants are already doing this. One paper coating plant has been using such distillation procedures since 1934. Distillation equipment can be expensive, however, and it is hard to build flexibility into a distillation system. Flexibility is needed because many paper coaters, especially those who do custom work for others, are constantly changing solvent formulations.

However, in some plants where mixed solvents are used, azeotropic mixtures can occur which can be separated only by specialized techniques. Even large coaters have commented that they did not have the knowledge at hand necessary for the complex distillation and separation procedures needed.

Another problem with carbon adsorption is the potential of generating explosive conditions in the adsorber because of the localized increases in combustible organic material concentrations. Ignition apparently can be caused by static electricity in systems where dry air at high flow rates is treated. Several explosions of absorbers have been reported in paper coating and other plants.

Also, adsorption of solvents containing water soluble compounds (such as alcohols, ketones or esters) can present a secondary pollution problem where steam is used for regeneration. Additional treatment of the condensed steam with its content of dissolved organics would be required, increasing the complexity of the solvent recovery system and its cost.

5.4 COST AND VOC REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

This section discusses the projected costs of control for paper coating in the state, based on the emission inventory developed by the Michigan Department of Natural Resources and information developed by EPA sources. Where possible, the validity of the costs were confirmed with coating firms and equipment manufacturers.

Though some coaters will substitute low solvent or solventless coating for current high solvent systems, no reliable information was available to estimate the amount of such coatings which might be used. Several coaters also commented that though they had low solvent coatings under development the coatings would not be sufficiently evaluated to meet proposed compliance schedules. Therefore, it has been assumed that either incineration or carbon adsorption will be used to comply with the proposed regulations.

5.4.1 Costs of Alternative Control Systems

Exhibits 5-10 and 5-11, on the following pages, present costs for typical incineration and carbon adsorption systems as developed by EPA sources.[1] Both systems are based on the assumption that exhaust air flow rates can be reduced sufficiently to attain LEL levels of 25 percent. This is possible with well-designed ovens where excess air can be reduced or where product characteristics allow.

Several paper coaters indicate that this may not be possible with older coating lines or with certain types of coating. Coating drying rate is a function of air flow rate, temperature and vapor concentration in the air. If air flow rates are to be reduced, drying temperatures or drying times must be increased. Because of the heat sensitivity of some coating, temperature increases may not be possible. Increase in drying time will necessitate either more time in the ovens or reduced production rates. Several coaters of heat sensitive products indicated that in order to achieve special characteristics they could not increase emission concentrations above 5 to 6 percent of LEL and could not use oven temperatures above 140°F. Plants manufacturing conventional coated products, however, can decrease air flow rates sufficiently to increase VOC concentrations in the exhausts to 40-50 percent with only moderate increases in temperatures or changes in production rates. We have assumed for cost estimation purposes that a 25 percent LEL can be attained on the average.

---

[1] Op. Cit. EPA 450/2-77-008

EXHIBIT 5-10
U.S. Environmental Protection Agency
INCINERATION COSTS FOR A TYPICAL PAPER
COATING OPERATION

Incineration Device	Installed Cost ($)	Annualized Cost ($/yr.)	Control Cost ($/ton of solvents recovered)
No heat recovery			
Catalytic	155,000	100,000	51
Noncatalytic (Afterburner)	125,000	105,000	54
Primary heat recovery			
Catalytic	180,000	75,000	39
Noncatalytic (Afterburner)	150,000	66,000	34
Primary and secondary heat recovery			
Catalytic	220,000	54,000[a]	28[a]
Noncatalytic (Afterburner)	183,000	26,000[a]	13[a]

Note: Typical operation parameters are: process rate of 15,000 scfm; temperature of 300°F, operation at 25 percent of LEC. See Volume I, Chapter 4, for costs for other operating parameters. Costs are believed to be valid only for mid-1974.

[a] Assumes heat is recovered and used at a total heat recovery of 70 percent.

Source: EPA-450/2-77-008

EXHIBIT 5-11
U.S. Environmental Protection Agency
CARBON ADSORPTION COSTS FOR PAPER COATING INDUSTRY

	Installed Cost ($)	Annualized Cost ($/yr.)	Control Cost ($ ton of solvent recovered)
No credit for recovered solvent	320,000	127,000	125
Recovered solvent credited at fuel value	320,000	60,000	40
Solvent credited at market	320,000	(100,000)[a]	(50)[a]

Note: Operating parameters are: process rate of 15,000 scfm, temperature of 170°F, operation at 25 percent of LEC. See Volume I, Chapter 4, for details on cost estimates. Costs are believed to be valid only for mid-1974.

a. Costs in parenthesis indicate a net gain.

Source: EPA-450/2-77-008

Both incinerator costs and adsorber costs are a function of equipment size and vary generally with air flow rate. It was assumed based on similar studies on paper coating in other states for projection of overall costs in the state that control equipment, on the average, would be sized for 2,800 scfm per unit. In most plants, it is impractical to manifold exhausts so that all exhausts could be treated in one add-on emission control system. In the case of incinerators, it would be difficult to use secondary heat recovery on ovens where the incinerator is remote from the oven. For this reason and the lack of detailed information on each plant, it was also assumed that only primary heat recovery would be used. This assumption only slightly decreases capital costs and has a moderate effect upon annualized costs since the higher capital costs associated with secondary heat recovery are offset by fuel savings.

Because of the lack of the suitability of recovered solvent for in-process uses, it was assumed that recovered solvent would only be credited at fuel values.

The major problem in estimating total installed costs of control systems is the added cost of installation. The EPA estimates were made on the assumption of an easily retrofitted system. In practice, coaters have found actual installed costs to be three to five times those summarized in Exhibits 5-10 and 5-11, which are based on costs in EPA 450/2-77-008, Control of Volatile Organic Emissions from Existing Stationary Sources.

The differences, other than for inflation caused cost increases, result from varying retrofit situations. In essentially all cases, the plants affected are old; installation of new air handling systems, coating line enclosure and the possible need for new ovens for other emission collection systems can be a sizeable portion of the cost of an overall emission control system. For instance, in one plant where a catalytic incinerator with secondary heat recovery was installed, total project cost was about five times the base price of the incinerator. The major cost was not the incinerator but the requirement for new ovens for emission collection.

The experience of E.I. DuPont de Nemours and of equipment manufacturers also illustrate the need to increase these previous EPA estimates. E.I. DuPont de Nemours, based on their experience on actual installed equipment, estimates[1] \$1.2 million for a carbon adsorber to treat 15,000 scfm of exhaust gases. Recent prices from manufacturers of recuperative-type incinerators for a 15,000 scfm direct-fired, ceramic bed primary recuperative heat exchanger are about \$150,000 for the incinerator alone;

---

[1] T.A. Kittleman and A.B. Akell, "The Cost of Controlling Organic Emissions," Chemical Engineering Progress, April 1978.

installed costs, with provision for return of exhausts for secondary heat recovery, are estimated to be more than \$300,000[1] The estimates in Exhibits 5-10 and 5-11 indicate installed costs of \$320,000 for an equivalent adsorber, and \$140,000 for the incinerator.

5.4.2 Estimated Statewide Costs

The total emissions considered to be applicable under RACT, as tabulated in Exhibit 5-8, are about 13,100 tons per year. In developing estimated costs of compliance by affected coaters, it was assumed that 75 percent of emissions would be controlled by incineration and the remaining 25 percent by carbon adsorption. In some cases, coaters would prefer to use low solvent or water-based coatings since these promise lower overall operating costs. However, since development of coatings and evaluation of coated products would require several years, it is not likely that use of these coating materials will have significant impact on control costs, if current compliance deadlines are to be met. The study team, therefore, considers that add-on control devices are the most likely method of control to be used to meet compliance deadlines and that, based on discussions with coaters, a 75 percent to 25 percent apportioning of incineration or carbon adsorption is the most appropriate. Mode of compliance can be identified further only by a detailed examination of the processes and coating materials used at each location and by in-depth cost analyses of compliance alternatives.

Based on the emission inventory as summarized in Exhibit 5-8 following page 5-12, 17 firms will probably be affected by the proposed regulations. Using an average of 2,800 scfm per add-on control device, the assumptions discussed in the previous section, a total of about 36 add-on control devices--nine carbon adsorbers and 27 incinerators--would be required. With incinerators assumed to provide only primary heat recovery and carbon adsorbers to have recovered solvent valued at fuel prices, costs were then obtained from Control of Volatile Organic Emissions from Existing Stationary Sources, Vol. I: Control Methods for Surface-Coating Operations, EPA-450/2-77-008. Key assumptions used here and in this report are summarized in Exhibit 5-12, on the following page.

These base costs were modified by multiplying capital costs by a factor of three and four and adjusting annual costs for inflation and the increased capital costs. As discussed above in Section 5.4.1, the base costs in the EPA-450-77-008 report are low by a factor of three to four, since they do not reflect difficult retrofit factors and other capital requirements in a complete emission control system and require updating to 1977.

---

[1] Discussions with REECO, Inc., Morris Plains, N.J. and Bobst-Champlain, Roseland, N.J.

EXHIBIT 5-12
U.S. Environmental Protection Agency
SUMMARY OF ASSUMPTIONS USED IN COST ESTIMATE

Assumptions

75 percent of emissions are controlled by incineration with primary and secondary heat recovery; 25 percent by carbon adsorption with recovered solvent credited at fuel prices

25 percent LEL is equal to 3,000 ppm of toluene by volume

Air flow can be reduced to reach 25 percent LEL

The price of a 2,800 SCFM system can be used as an average. No costs are added for distillation or additional waste disposal.

13,100 tons of emissions are treated per year over an operating period of 5,840 hours per year.

Other assumptions regarding incinerator and adsorber prices, as estimated in Control of Volatile Organic Emissions from Existing Stationary Sources, Vol. I: Control Methods for Surface-Coating Operations, EPA-450/2-76-008, are valid.

Source: Booz, Allen & Hamilton Inc.

Using these cost estimating procedures, total capital costs of compliance are estimated to range from $13 million to $16 million, with equivalent annualized costs of $3.2 million to $4.7 million. As stated earlier in this report, total emission sources identified probably represent at least 90 percent of the paper coaters identified. These costs similarly are expected to represent at least 90 percent or better of the papercoating RACT compliance costs for the state.

5.4.3 Estimated Emission Reduction

Assuming that 90 percent of all solvents used in coating operations can be collected by properly designed hoods and ovens, emissions could be reduced by 10,500 tons per year. This is based on a 90 percent capture of emissions by a carbon adsorber or destruction in an incinerator, an overall reduction in emissions of 81 percent.

5.5 DIRECT ECONOMIC IMPACTS

This section presents the direct economic implications of implementing the RACT guidelines for surface coating of paper on a statewide basis. The analysis includes the availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost pass-through), state economic variables and capital investment.

5.5.1 RACT Timing

Current proposed guidelines for paper coating suggest several compliance deadlines for alternative methods of compliance.[1] Generally, for add-on systems they call for installation of equipment and demonstration by mid-1980 or late 1980; for low solvent systems, by late 1980 or mid-1981, depending upon the degree of research and development needed. Major coaters, material suppliers and equipment manufacturers believe these deadlines to be unattainable.

- Normally, large incinerator and carbon adsorption systems will require about a year or more from receipt of purchase to install and start up the system. Engineering may require three months or more, fabrication three to six months and installation and startup as long as three months. A major coater with considerable experience with similar installations estimates that the complete cycle of installation, from initial selection of control method to testing of the system, would require 37 months plus an additional 12 months to establish an economically sound method of control.

- Only a small number of companies manufacture incineration systems with proven high heat recovery. The cumulative effect of equipment requirements by all firms in the U.S. needing control devices could severely impede the ability of these firms to supply equipment. In some cases, the most efficient devices are only now undergoing initial trials, and no production capacity has been developed.

---

[1] Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001

- A major coating firm estimates that the use of low solvent or solventless coatings may take as long as 68 months from initial research, through product evaluation and customer acceptance to final production. Product and process development alone may take as long as 24 months and product evaluation over 14 months. These comments are in general agreement with those made by other coaters.

In general, it appears that if either add-on control systems are used or new low solvent systems need to be developed, deadlines must be extended.

5.5.2 Technical Feasibility Issues

Though low solvent or solventless materials are used in many paper coating operations at present, many types of solvent-based systems have no satisfactory replacement. The alternative materials do not meet the product quality standards demanded by the coaters. Additional development is needed and will require the combined efforts of both the coaters (who must maintain product quality) and the coating material suppliers. Ideally, the new coating materials should be adaptable to existing coating equipment to minimize additional capital investment.

As discussed above, both incineration and carbon adsorption are not completely satisfactory add-on control systems. Incineration requires large volumes of additional fuel if good heat recovery is not accomplished; carbon adsorption is not usable on many coating systems because of the multiplicity of compounds used in solvent mixtures.

5.5.3 Comparison of Direct Cost with Selected Direct Economic Indicators

The net increase in annualized costs to coaters was estimated at \$3.2 million to \$4.7 million. These additional costs are projected to represent 1.0 percent to 1.5 percent of the total annual value of shipments (about \$300 million) of the firms identified to be affected by the proposed regulations. Assuming a "direct pass-through" of these costs, prices will increase by about the same fraction.

The major economic impact in terms of cost to most individual companies will be the large capital expenditures required for add-on devices, rather than increased annualized costs. For most companies, these costs would exceed their current level of capital expenditures for plant improvement and expansion. A large pressure-sensitive paper coater in the state, for instance, has estimated that a capital investment of about \$2 million would be needed to meet proposed guidelines. His current capital expenditure program is normally in the range of \$1.5 million.

A typical case is a Michigan firm which manufactures various types of recording paper and produces 40 percent of the electrocardiogram paper used in this country. Although with additional development some of its coating solutions could be replaced with low solvent or waterborne ones, incineration or carbon adsorption would be the only method of complying with the regulation as now proposed. Based on projected costs for either of these add-on control systems, the firm is seriously considering terminating or moving operations. Similar financial difficulties are foreseen for marginally profitable firms which have limited capital access or for which the added annual costs of compliance are prohibitive.

Similar comments have been obtained from other coaters, particularly small ones, who believe that the capital cost of add-on controls will present a major capital acquisition problem.

5.5.4 Selected Secondary Economic Impacts

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

Employment is expected to be only moderately affected. Employment would be reduced if marginally profitable facilities closed, but the present indication from the industry is that plant closures may occur only for small firms with limited capital access. However, even large firms may be forced to close down marginally profitable coating lines with a resultant decrease in employment.

It is likely that market structure may be affected by the closure of firms with limited capital access, with their sales being absorbed by larger firms. The number of closures, however, is expected to be small if capital resources can be made available to the companies, since operating costs have only a small effect on sales prices and would be the same for all firms affected.

No significant effect on overall productivity is foreseen except for a small change resulting from the need for add-on control system operating and maintenance personnel.

*   *   *   *

Exhibit 5-13, on the following page, summarizes the conclusions reached in this study and the implications of the estimated costs of compliance for paper coaters.

EXHIBIT 5-13
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR PAPER COATERS
IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	Approximately 30 plants have been identified from the emission inventory. About 17 of these would be affected by the regulations. However, if this category is interpreted to include all types of paper coating, including publishing far more firms would be affected.
Indication of relative importance of	The 1977 value of shipments of the 30 plants identified is estimated to be approximately $300 million. These plants employment is estimated to be approximately 3,500
Current industry technology trends	Gravure coating replacing older systems
1977 VOC emissions (actual)	Approximately 13,000 tons per year were identified from the emission inventory. Actual emissions are expected to be higher.
Industry preferred method of VOC control to meet RACT guidelines	Though low solvent coating use is increasing, progress is slow. Add-on control systems will probably be used.
Assumed method of control to meet RACT guidelines	Thermal incineration with primary and secondary heat recovery

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	Estimated to be $13 million to $16 million depending on retrofit situations. This is likely to represent greater than 100 percent of normal expenditures for the affected paper coaters.
Annualized cost (statewide)	$3.2 million to $4.7 million annually. This represents approximately 1.0 to 1.5 percent of the 1977 annual sales for the affected paper coaters.
Price	Assuming a "direct cost pass-through"--1.0 to 1.5 percent
Energy	Assuming 35 percent heat recovery annual energy requirements are expected to increase by approximately 55,000 equivalent barrels of oil annually.
Productivity	No major impact
Employment	No major impact
Market structure	Smaller firms may be unable to secure capital funding for add-on systems, which are typically $250,000 or more for a moderate sized incinerator to over $1 million for a carbon adsorber.
RACT timing requirements (1982)	RACT guideline needs clear definition for rule making. Equipment deliverables and installation of incineration systems prior to 1982 are expected to present problems
Problem areas	Retrofit situations and installation costs are highly variable Type and cost of control depend on particular solvent systems used and reduction in air flow

EXHIBIT 5-13(2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
VOC emissions after RACT control	2,500 tons/year (20 percent of 1977 VOC emission level)
Cost effectiveness of RACT control	$300 - $450 annualized cost/annual ton of VOC reduction

Note: Cost data is based on emission information supplied by the Michigan Department of Natural Resources

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Davidson's Textile Blue Book, 1977.

T. W., Hughes, et al., Source Assessment: Prioritization of Air Pollution from Industrial Surface Coating Opeations, Monsanto Research Corporation, Dayton, Ohio. Prepared for U.S. Environmental Protection Agency, Research Triangle Park, N.C., under Contract No. 68-02-1320 (Tech. 14) Publication No. 650/2-75-019a.

T. A. Kittleman and A. B. Akell, "The Cost of Controlling Organic Emissions," Chemical Engineering Progress, April 1978.

Lockwoods Directory of the Paper Industry, 1977.

Springborn Laboratories, Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report. EPA Contract No. 68-0202075, August 23, 1977.

State Industrial Directories Corporation, 1978-79 Michigan State Industrial Directory, 1978.

Thomas Register of American Manufacturers, 1978.

U.S. Environmental Protection Agency, Control of Volatile Organic Emissions from Existing Stationary Sources, Volume I. EPA-450/2-76-028, May 1977.

U.S. Environmental Protection Agency, Regulatory Guidance for Control of Volatile Organic Compounds Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001, April 1978.

U.S. Department of Commerce, Annual Survey of Manufactures, 1976.

U.S. Department of Commerce, County Business Patterns, 1976.

U.S. Department of Commerce, Census of Manufactures, 1972.

Private conversation with:

Armak Co.	Marysville, MI/Alliance, OH
American Can Co.	Greenwich, CT
Fasson	Painesville, OH
Presto Adhesive Paper Co.	Miamisburg, OH
3M Company	St. Paul, MN
Morgan Adhesives	Milan, OH
National Flexible Packaging Assn.	Cleveland, OH
Pressure Sensitive Tape Council	Chicago, IL
Continental Can Co.	Newark, OH
General Electric Co.	Coshocton, OH
Mead Corp.	Chillicothe, OH
St. Regis Paper Co.	Battle Creek, MI/Troy, OH
World Wild Games	Radnor, OH
TEC Systems	DePere, WI
Overly Inc.	Neenah, WI
Bobst-Champlain	Roseland, NJ
REECO, Inc.	Morris Plains, NJ
Arvey Corp.	Chicago, IL
Bagcraft Corp. of America	Chicago, IL
Chicago Decal Co.	Chicago, IL
Diamond T. Packaging Corp.	Addison, IL
Engineering Coated Products, Inc.	Northbrook, IL
Joanna Western Mills	Chicago, IL
Ludlow corp.	Chicago, IL
Meyercord	Carol Stream, IL
Nabisco	Marseilles, IL
Nashua	Chicago, IL
Standard Pckaging	Elgin, IL
Weber Marking Systems	Arlington Hts., IL
Weber Valentine Co.	Elk Grove, IL
Weldon Industries	Harvey, IL
Cadillac Products	Warren, MI
C&S Carton, Incorporated	Marshall, MI
St. Regis Paper Company	Battle Creek, MI
Muskegon Paper Box Company	Muskegon, MI
Packaging Corp. of America	Portage, MI
Packaging Corp. of America	Grand Rapids, MI
Packaging Corp. of America	Grandville, MI
Potlatch Forrest, Incorporated	St. Joseph, MI
Continental Can Company	Three Rivers, MI
Greif Brothers Corporation	Wyondotte, MI
Union Camp Corporation	Monroe, MI
Consolidated Packaging Corp.	Monroe, MI
Armak Company	Marysville, MI
Label Technique, Incorporated	Sturgis, MI
Simplex Industries	Constantine, MI
Quality Park Products	Birmingham, MI
Graphic Controls Corporation	Alpena, MI
Proctor & Gamble Paper Products	Cheboygan, MI

6.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING FABRICS IN THE STATE OF MICHIGAN

6.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING FABRICS IN THE STATE OF MICHIGAN

This chapter presents a detailed analysis of the impact of implementing RACT for plants in the State of Michigan which are engaged in the surface coating of fabrics and vinyls. This RACT category is meant to include the roll, knife or rotogravure coating and oven drying of textile fabrics (to impart strength, stability, appearance or other properties), or of vinyl coated fabrics or vinyl sheets. It includes printing on vinyl coated fabrics or vinyl sheets to modify appearance but not printing on textile fabrics for decorative or other purposes. It does not, however, include the coating of fabric substrates with vinyl plastic polymers which are usually applied as melts or plastisols that result in only minor amounts of emissions. The chapter is divided into six sections:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Alternative control methods
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines; previous studies of fabric coating; interviews with fabric and vinyl coaters, coating equipment and materials manufacturers and add-on control equipment manufacturers; and a review of pertinent published literature.

6.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impacts

for plants in the state engaged in the surface coating of fabrics and vinyls. The quality of these estimates is discussed in the last part of this section.

6.1.1 Industry Statistics

The coating of fabrics is used to produce a large variety of common consumer and industrial products. Typical products are raincoats, upholstery, wall covering, tablecloths, window shades, gasketing, diaphragms, lifeboats and bookcovers. In most cases the finished product is manufactured by firms who purchase the coated fabric from a manufacturer whose principal activity is fabric coating. However, there are a number of vertically integrated firms (the major automobile manufacturers are typical) which both coat fabrics and manufacture finished goods from them. Other exceptions are firms which both manufacture fabrics and coat them. Thus firms which coat fabrics or vinyl coated fabrics or sheeting can be found in a number of Standard Industrial Classification categories; these are listed below:

SIC	Description
2211	Broad woven fabric mills, cotton
2221	Broad woven fabric mills, man-made and silk
2241	Narrow fabrics and other, small wares mills
2258	Warp knit fabric mills
2261	Finishers of broad woven fabrics of cotton
2262	Finishers of broad woven fabrics of man-made fiber and silk
2269	Finishers of textiles, n.e.c.*
2295	Coated fabrics, not rubberized
2297	Nonwoven fabrics
3069	Fabricated rubber products, n.e.c.*
3079	Miscellaneous plastics products
3291	Abrasive products
3293	Gaskets, packing, sealing devices

*not elsewhere classified

General statistics concerning the firms included in these SIC groupings were obtained from the most recent Census of Manufactures, County Business Patterns and other economic summaries published by the U.S. Department of Commerce.

Data on industrywide shipments of coated fabrics were obtained from the Textile Economics Bureau (New York City, N.Y.). Identification of individual candidate firms which might be affected by the proposed regulation was made by review of industry directories:

- Davidson's Textile Blue Book
- Rubber Red Book
- Modern Plastic Encyclopedia
- Thomas Register of American Manufacturers
- Michigan Directory of Manufacturers
- Membership list of the Canvas Products Association.

In addition, the Michigan Department of Natural Resources 1977 emission inventory was scanned for firms listed in each of the SIC groupings tabulated above. An exhaustive telephone survey was made to verify the activities of candidate firms which would be affected by this RACT category. Only three companies could be found which coat either fabric or vinyl coated materials, by the methods specified in the proposed regulations, and are expected to be affected by the regulations. One of these, the Ford Motor Company, was interviewed in person by study team members; the other two were interviewed by telephone. Though there may be other unidentified plants in the state which coat fabrics as defined under the RACT category, they are few in number with minimal emissions.

6.1.2 VOC Emissions

The Michigan Department of Natural Resources emission inventory was used as a basis for the estimation of the total VOC emissions from the fabric coating plants identified. The emission rates were confirmed in interviews by the study team with the firms concerned and thus are believed to be valid. They represent 90 percent or more of the emissions in this RACT category. Emissions from fabric coating plants not identified in the state, if they exist, are expected to be small and negligible.

6.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions from fabric coating processes are described in Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-77-008). The report suggests the use of various low solvent or solventless coatings which have found some use in the industry, as well as add-on devices, such as incinerators or carbon adsorbers. The three firms expected to be affected by the regulation in Michigan indicated in interviews that incineration was the only reasonably available emission control technology applicable to their coating processes at this time. Waterborne or low solvent coatings are either currently unavailable for their product lines or of limited applicability. Carbon adsorption was unsuitable because of high capital costs, complexity of solvent recovery after regeneration, or the impracticality of solvent reuse.

6.1.4 Cost of Control and Estimated Reduction of VOC Emissions

The overall costs of control of VOC emissions were determined by:

- An independent estimate of control costs by the study team based upon emissions obtained from the Michigan Department of Natural Resources inventory

- Estimates provided to the study team in interviews with the companies expected to be affected by the regulations.

The independent estimate used design and cost information provided by incinerator manufacturers or available in the published literature and in the following EPA reports:

- Control of Volatile Organic Emissions from Existing Stationary Sources, Volume I (EPA-450/2-76-028)

- Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories.

Estimates of emission reduction are largely dependent upon the efficiency with which solvents can be collected from the coating operation. In formulation of the proposed regulation EPA has estimated that, by proper collection system design, at least 90 percent of the solvents in the applied coating material can be collected. This 90 percent is not meant to include solvents which might be lost in the compounding of the coating or used for cleaning of the process equipment or fabric. This collection efficiency combined with a 90 percent emission reduction efficiency by incineration or carbon adsorption can reduce emissions by 81 percent overall.

6.1.5 Economic Impacts

The economic impacts were determined by: analyzing the lead time requirements to implement RACT; assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability; comparing the direct costs of RACT control to various state economic indicators; and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Michigan. Since three companies appear to be affected, detailed statements concerning the impact of the regulations upon certain individual economic factors are not possible. Proprietary information, such as annual capital expenditures and value of shipments, is not available.

6.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of fabrics in Michigan. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that are available for the base year), "B" indicates data that were extrapolated from hard data and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 6-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 6-1

U.S. Environmental Protection Agency

DATA QUALITY--SURFACE COATING OF FABRICS

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics	X		
Emissions	X[a]		
Cost of emissions control			X
Economic impact			X
Overall quality of data		X	

---

[a] Emission data supplied by Michigan Department of Natural Resources, state emission inventory.

Source: Booz, Allen & Hamilton Inc.

6.2 INDUSTRY STATISTICS

Industry characteristics, statistics, and trends for fabric coating are presented in this section. This information forms the basis for assessing the total impact of implementing RACT for control of VOC emissions in this category upon the state economy and upon the individual firms concerned. The effects upon the firms involved are somewhat different because of their relative sizes, though proportionately the effects are similar.

6.2.1 Size of the Industry

The Bureau of Census, in 1976 County Business Patterns, reported a total of about 610 plants in SIC categories in which plants coating fabrics in Michigan would be expected to be tabulated.

Pertinent data concerning these plants are summarized in Exhibit 6-2, on the following page. As mentioned earlier based on a review of industrial directories and other published information, and a multitude of telephone interviews, only three plants were found in which fabric coating, as defined in the proposed "fabric coating" regulation, was being done. Statistics concerning these three plants are summarized in Exhibit 6-3, following Exhibit 6-2.

As shown, these three firms are estimated to employ a total of about 1,600 people. They are estimated to have an annual value of shipments of about $100 million collectively. Individual estimated annual value of shipments are not tabulated to protect proprietary information.

6.2.2 Comparison of the Industry to the State Economy

A comparison of the value of shipments of these plants with the state economy indicates that these plants represent over 0.012 percent of the total value shipments by manufacturing plants and employ about 0.16 percent of manufacturing workers in Michigan.

6.2.3 Historical and Future Patterns of the Industry

The fabric coating industry in the U.S., except for the general economic slump in 1975, has shown a gradual but steady growth in sales and shipments over the last several years as demonstrated by Exhibits 6-4 and 6-5, following Exhibit 6-3. The largest growth in terms of dollar value of shipments was for vinyl coated fabrics which increased by $215.5 million in shipments from 1972 to 1976, compared with an increase of $301 million for all coated fabrics. Pyroxylin (cellulose nitrate) coatings,

EXHIBIT 6-2
U.S. Environmental Protection Agency
INDUSTRY STATISTICS FOR PLANTS IN SIC CATEGORIES
WHERE FABRIC COATING MAY BE USED IN MICHIGAN

SIC	Name	Number of Firms	Number of Employees	Annual Payroll ($000s)
2211	Broad woven fabric mills, cotton	1-2	a	a
2221	Broad woven fabric mills, man-made and silk	1-2	a	a
2241	Narrow fabrics and other, small wares mills	1-2	a	a
2258	Warp knit fabric mills	4	350	a
2261	Finishers of broad woven fabrics of cotton	1	350	a
2262	Finishers of broad woven fabrics of man-made fiber and silk	1	60	a
2269	Finishers of textiles, n.e.c.	1	180	a
2295	Coated fabrics, not rubberized	6	1,750	a
2297	Nonwoven fabrics	2	350	a
3069	Fabricated rubber products, n.e.c.	58	3,500	a
3079	Miscellaneous plastics products	456	21,647	214,973
3291	Abrasive products	47	1,644	21,263
3293	Caskets, packing, sealing devices	29	1,656	21,020
		608-611	31,487	

---

a. Not reported to protect proprietary information.

Source: 1976 *County Business Patterns*, U.S. Department of Commerce.

EXHIBIT 6-3

U.S. Environmental Protection Agency

FIRMS EXPECTED TO BE AFFECTED BY THE FABRIC COATING RACT REGULATIONS IN MICHIGAN

Firm	Location	Employees	Estimated Fabric Coating Emission Tons/Year	Activity
Ford Motor Company Vinyl Plant	Mt. Clemens	1,269	2,700	Vinyl Coating
Rospatch Label Company	Grand Rapids	215	15	Fabric Label Coating
St. Clair Rubber Company	Marysville	100(est.)	303	Rubber Coating of Fabrics
		1,584	3,018	

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 6-4
U.S. Environmental Protection Agency
U.S. ANNUAL VALUE OF SHIPMENTS OF COATED FABRICS
($ millions)

Item	1972	1973	1974	1975	1976
Pyroxylin-Coated Fabrics	26.3	27.3	34.5	28.0	32.5
Vinyl Coated Fabrics	601.9	693.7	728.7	681.5	817.4
Other Coated Fabrics	154.1	188.0	212.6	202.7	213.8
Coated Fabrics, not rubberized	26.3	29.4	(13.6)[a]	(1.4)[a]	(33.8)[a]
Rubber Coated Fabrics	67.9	73.6[b]	83.5[b]	72.0[b]	80.0[b]
TOTAL	876.5	1,011.9	1,156.5	985.6	1,177.5

Notes:

a. Values obtained by difference from gross shipments of all coated fabrics, not rubberized

b. Booz, Allen estimate based on shipments of "Other Rubber Goods, N.E.C.", SIC Code 30698

Source: 1976 Annual Survey of Manufactures

EXHIBIT 6-5

U.S. Environmental Protection Agency

U.S. ANNUAL SHIPMENTS OF BACKING MATERIALS FOR COATED FABRICS

(in millions of pounds)

	1972	1973	1974	1975	1976
Transportation Fabric, all fibers[a]	95.4	100.9	64.6	65.3	81.5
Coated and Protective Fabrics[b]	133.7	149.3	167.5	137.8	177.6
TOTAL	229.1	250.2	232.2	203.1	259.1

Notes:

a. Transportation fabric includes auto seat upholstery and slipcovers, sidewall, headlining and sheeting. The cotton poundage include the knit and woven fabric used as the backing for vinyl sheeting. The item includes convertible auto tops & replacements thereof, as well as upholstery used in other kinds of transportation, such as airplanes, railroad & subway cars, buses, etc. It does not include seat padding, transportation rugs, window channeling flocking, tassels, trim, etc., or the textile glass fiber used in reinforced plastic seating for subways, buses, etc.

b. Coated and protective fabrics includes parachutes, deceleration chutes and tow targets; awnings; beach, garden & tractor umbrellas; inflatable dunnage and cushions, air-supported structures and automotive air-spring diaphragms; boat and pool covers; tarpaulin covers for athletic fields, etc.; also, the substrates used for vinyl sheeting. The cotton poundage include awnings, boat covers, tarpaulins and tents. Not included here are the cotton poundages used for vinyl substrates. Such poundages are tabulated with their appropriate end use, i.e., transportation upholstery, upholstery etc. Does not include man-made fiber surfaces for recreational fields.

Source: Textile Economics Bureau, Technicon, November 1977 because of their low cost and ease of application still continue to occupy a steady though proportionately smaller share of the market. Natural and artifical rubber coated fabrics, because of unique properties not obtainable with plastic materials, also maintain a substantial (about 10 percent) share of the coated fabric market. Vinyl and urethane coatings, however, are replacing a larger share of both markets.

Vinyl, urethane and synthetic rubber are the principal coating materials used by the companies in Michigan identified to be affected by the proposed regulations. Vinyl coatings are by far those in greatest use in the state since the major coater is the Ford Motor Company plant in Mt. Clemens. The quantities used are largely determined by the sales of Ford motor cars and trucks since the principal use of the vinyl fabrics produced at the plant is as upholstery, hard top or lining material.

6.3 TECHNICAL SITUATION IN THE INDUSTRY

This section describes the principal materials and processes used in fabric and vinyl coating and various methods which are considered to be reasonably available control technology to meet proposed regulations. The proposed RACT guidelines for fabric coating and an estimate of the total VOC emission reduction possible if the guidelines are implemented in the state are also presented.

6.3.1 General Coating Process Description

Fabrics are coated primarily to render them resistant to penetration by various fluids or gases, improve abrasion resistance or modify the appearance or texture. Typical examples are materials used in shower curtains; rubber life rafts; balloons; drapery material; synthetic leathers for shoes, upholstery or luggage; table cloths; and outdoor clothing. The base fabrics can be asbestos fiber cloth, burlap and pite, cotton drill, duck canvas, glass fabrics, knit cotton or rayon, nonwoven fabrics or nylon sheeting. In the case of coating of vinyls, the substrate is a flexible vinyl sheet or cloth-supported vinyl on which a coating is applied to enhance the appearance or durability of the vinyl surface.

Typical coating materials are rubber compounds, vinyl resins of various types, polyesters, polyurethanes, nitrocellulose resins, oleo resins, phenolic resins, epoxy resins and polyethylene. Various techniques are used for applying these coatings as melts, plastisols, latexes, solutions or other forms. Since these proposed guidelines are primarily concerned with coatings applied as solutions, where large volumes of volatile organic materials can be emitted, the following discussions will be limited primarily to processes for coating with coating materials dissolved in organic solvents.

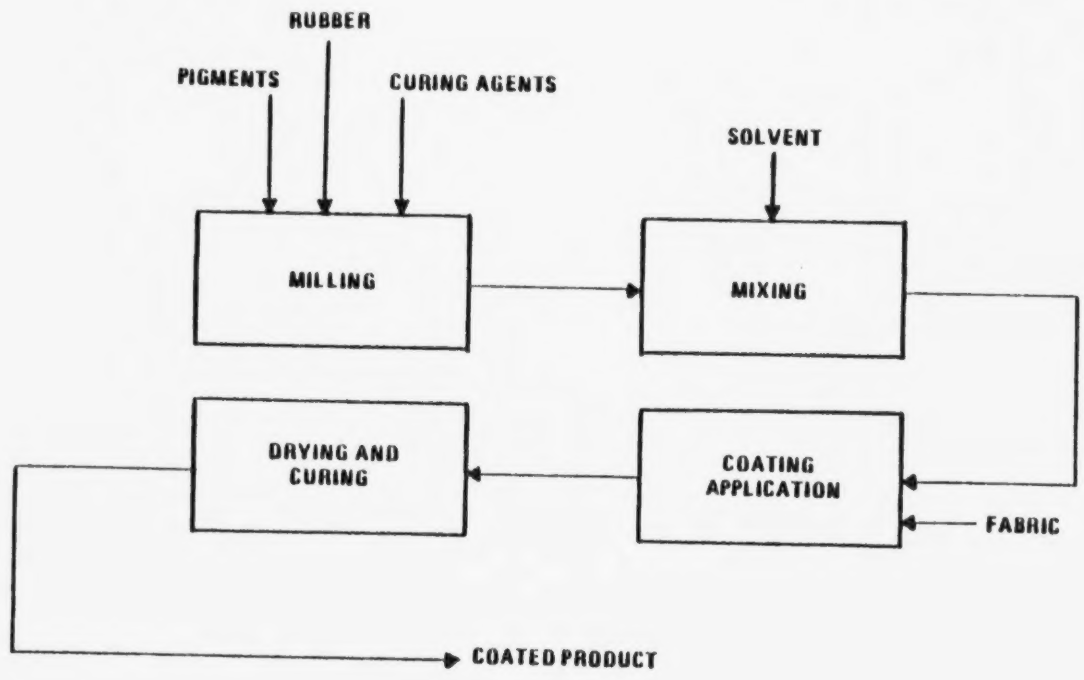
Exhibit 6-6, on the following page, shows the general operations involved in most fabric or vinyl coating operations. Four basic operations are involved:

- Milling -- Milling is primarily restricted to coatings containing rubber. Natural and synthetic rubbers are usually milled with pigments, curing agents and fillers to produce a homogeneous mass that can be dissolved in a suitable solvent. Organic solvents are not usually involved in the milling process; thus, there are seldom any organic emissions from this operation.

EXHIBIT 6-6

U.S. Environmental Protection Agency

TYPICAL FABRIC COATING OPERATION


RUBBER
PIGMENTS
CURING AGENTS
SOLVENT
MILLING
MIXING
DRYING AND CURING
COATING APPLICATION
FABRIC
COATED PRODUCT

Source: Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-76-028)

- Mixing -- Mixing is the dissolution of solids from the milling process in a solvent. The formulation is usually mixed at ambient temperatures. Sometimes only small fugitive emissions occur. However, some vinyl coaters estimate that as much as 25 percent of plant solvents are lost in mixing operations.

- Coating Application -- Fabric is usually coated by either a knife or a roller coater. Both methods are basically spreading techniques used for high speed application of coatings to flat surfaces. In some unique situations, dip coating may be used.

- Drying and Curing -- Finally, the coating is dried or cured in a final operation using heat or radiation to remove the solvents or set the coating.

In general, the coating line is the largest source of solvent emissions in a fabric coating plant, and the most readily controllable. Some coating plants report that over 70 percent of solvents used within the plant are emitted from the coating line. Other plants, especially those involved in vinyl coating, report that only 40 to 60 percent of solvents purchased by the plant are emitted from the coating line. Remaining solvents are lost as fugitive emissions from other stages of processing and in cleanup. These fugitive losses are generated by:

- Transfer from rail cars or tank trucks to storage tanks, and subsequent transfer to processing tanks

- Breathing losses from vents on storage tanks

- Agitation of mixing tanks which are vented to the atmosphere

- Solvent evaporation from cleanup of the coating applicator when coating color or type is changed

- Handling, storage and disposal of solvent soaked cleaning rags

- Waste ink disposal -- Waste ink is usually distilled to recover much of solvent. After distillation the sludge, which still contains some solvent, is usually dumped in a landfill

- Losses from drums used to store coatings which are being pumped onto a coating applicator. These are usually drums which are not hooded and may not even be covered

- Cleaning empty coating drums with solvent

- Cleaning coating lines with solvent

- Evaporation of solvent from the coated fabric after it leaves the coating line. From 2-3 percent of total plant solvent usage remains in the product. Half of this may eventually evaporate into the air.

Control techniques for the above types of sources include tightly fitting covers for open tanks, collection hoods for areas where solvent is used for cleanup and closed containers for solvent wiping cloths.

6.3.2 Nature of Coating Materials Used

Coating formulations used in organic solvent-borne coatings normally incorporate film-forming materials, plasticizers, pigments and solvents. A multitude of organic solvents are used; solvents such as acetone toluene, heptane, xylene, methyl ethylketone, isobutyl alcohol and tetrahydrofuran are widely used in rubber, vinyl and urethane coating formulations.

In some cases, a single solvent is used, but more generally mixed solvents are employed to obtain optimum drying rates and coating mixture properties. Too rapid drying results in undesirable surface properties such as "orange peel" or other effects; improper viscosity or solvency of the coating mixture may prevent proper coating of the substrate; slow drying can limit production rates.

As discussed earlier, a number of film-forming materials are used. Typical coating materials are epoxy resins, melamine-formaldehyde resins, nitrocellulose resins, oleoresinous compounds, phenolic resins, polyesters, polyurethanes, rubber compounds and vinyl resins. Miscellaneous resins such as polyethylene and ethylene copolymers, starch and casein compounds, and acrylic resins are not discussed here since most use coating techniques which are not solvent related.

Plasticizers are added where the flexibility of the coating is important, such as in clothing or upholstery fabric. Pigments or opacifiers are added to clear film formers to provide the colors or other appearance effects desired or are used in inks as a separate coating operation to modify the surface of the coating. Pigments applied as a printed coating are normally further coated with a clear finish coat to provide the luster desired and provide protection from wear.

6.3.3 Coating Processes Commonly Used

Exhibits 6-7 and 6-8, on the following pages, illustrate the two major methods of applying solvent-based coatings--knife coating and roll coating.

- Knife coating is probably the least expensive method. The substrate is held flat by a roller and drawn beneath a knife that spreads the viscous coating evenly over the full width of the fabric. Knife coating may not be appropriate for coating materials such as certain unstable knitgoods, or where a high degree of accuracy in the coating thickness is required.

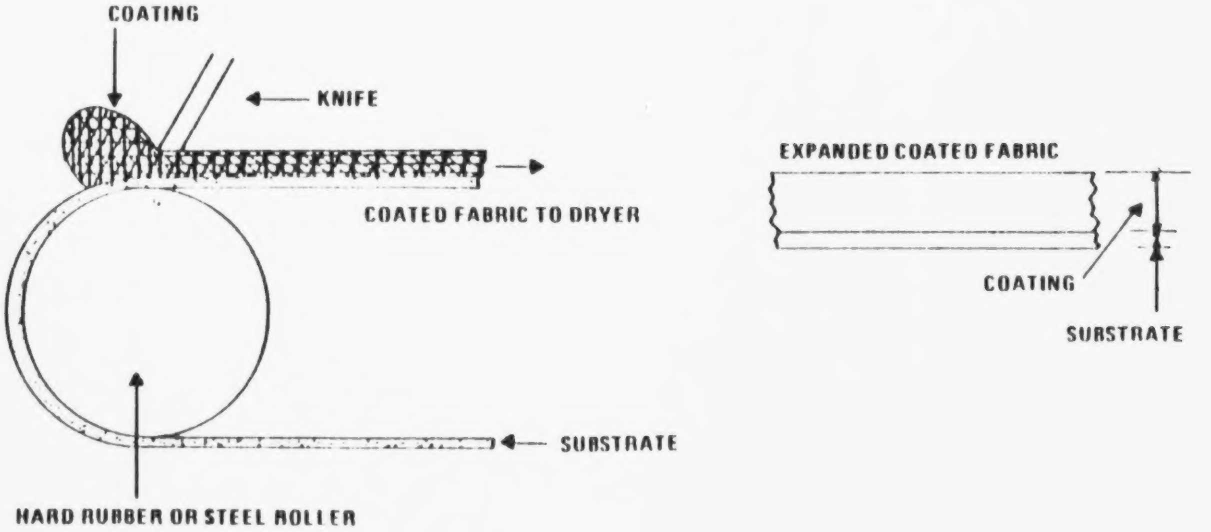
- Roller coating is done by applying the coating material to the moving fabric, in a direction opposite to the movement of the substrate, by hard rubber or steel rolls. The depth of the coating is determined by the gap between rolls (A and B as shown in Exhibit 6-7). The coating that is transferred from A to B is then transferred to the substrate from roll B. Unlike knife coaters, roller coaters apply a coating of constant thickness without regard to fabric irregularities.

Rotogravure printing is widely used in vinyl coating of fabrics and is a large source of solvent emissions. Rotogravure printing uses a roll coating technique in which the pattern to be printed is etched as a series of thousands of tiny recessed dots on the coating roll. Ink from a reservoir is picked up in these recessed dots and is transferred to the fabric surface. Shadow prints are used to simulate leather grain. A variety of patterns are printed on such items as vinyl wall paper. A transparent protective topcoat over the printed pattern is also applied with rotogravure techniques.

EXHIBIT 6-7

U.S. Environmental Protection Agency

KNIFE COATING OF FABRIC

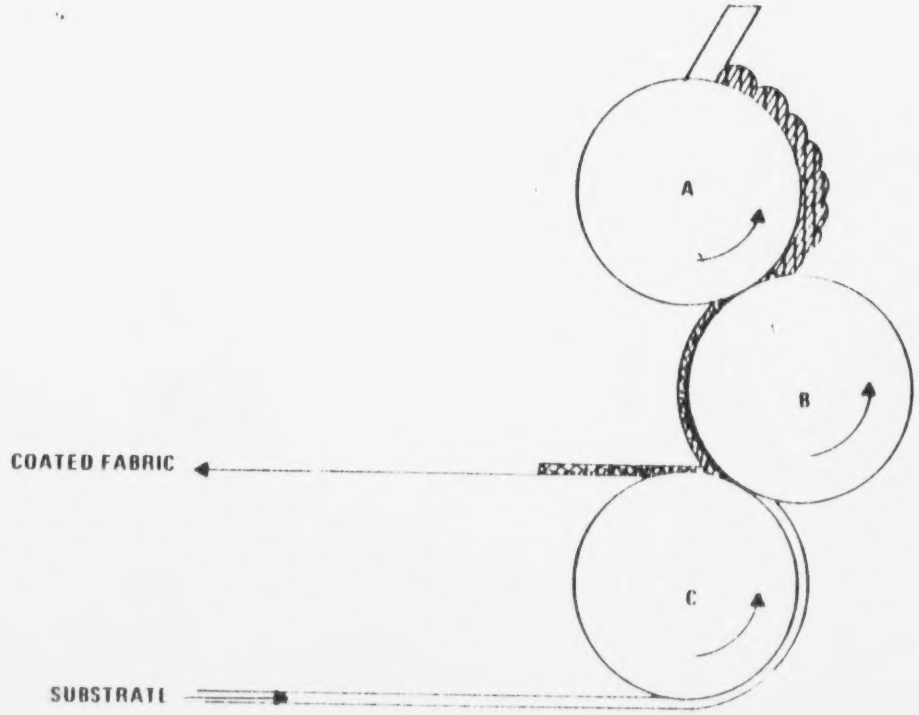

COATING
KNIFE
COATED FABRIC TO DRYER
HARD RUBBER OR STEEL ROLLER
SUBSTRATE
EXPANDED COATED FABRIC
COATING
SUBSTRATE

Source: Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-76-028)

EXHIBIT 6-8

U.S. Environmental Protection Agency

ROLLER COATING OF FABRIC


A
B
C
COATED FABRIC
SUBSTRATE

Source: Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-76-028)

Solvent emissions from the coating applicator account for 25 to 35 percent of all solvent emitted from a coating line. This solvent may be collected by totally enclosing the coating applicator in a small room or booth and sending all booth exhaust to a control device. However, a total enclosure of the coater may be difficult to retrofit on many existing lines. Another alternative is to cover the coater with a hood which can collect most of the solvent emissions.

The final operation in the coating process is the drying and curing of the applied coating material. Sixty-five to 75 percent of solvent emissions from the coating line usually occur in this step. In most ovens, almost all solvent emissions are captured and vented with exhaust gases. On some coating lines the emissions from the coating applicator hood are ducted to the oven and included with the oven exhaust.

Estimated and reported solvent concentration levels from drying operations range between 5 and 40 percent of the LEL (lower explosion limit). Typically, drying ovens are designed to process fabric on a continuous basis, operating with a web or conveyor feed system. Ovens can be enclosed or semienclosed and, depending on size, may exhaust from a few thousand to tens of thousand of cubic feet per minute of air. If an add-on control device is to be installed, it is generally in the owner's best interest to minimize the volume of air since the cost of add-on control devices is largely determined by the amount of air treated.

The oven heat increases the evaporation rate of the solvent and, with some coatings, will produce chemical changes within the coating solids to give desired properties to the product. In many cases, evaporation rates are controlled to give the desired properties to the coated fabric.

Many drying ovens in older plants are only semienclosed. As a consequence, they draw in excessive dilution air. Solvent concentrations range between 5 and 12 percent of the LEL according to both calculations and reports by industry. However, levels of up to 50 percent of the LEL are possible if proper safety devices are used. At least three plants in the United States are operated at 40 to 50 percent of LEL.

6.3.4 Emissions and Current Controls

As discussed earlier, only three major fabric or vinyl coaters have been identified in Michigan. The total VOC emissions from coating lines is estimated to be 3,000 tons for these three plants with the majority of this, about 2,700 pounds per year, originating at the Ford Motor Company vinyl coating plant in Mt. Clemens. These emissions are reported to be primarily methyl ethyl ketone.

Except for the planned installation of an incinerator system at the Ford Mt. Clemens plant, no controls are now used by the three plants.

6.3.5 RACT Guidelines

The RACT guidelines for control of VOC emissions from fabric coating require that emissions from coating lines be limited to a level of 2.9 pounds per gallon of coating for coating of fabric substrates and 3.8 pounds per gallon for coating of vinyl substrates. Both limits are based upon the use of an add-on device which recovers or destroys 81 percent of the VOC introduced in the coating. This the U.S. EPA considers to be achievable by capture of 90 percent of the VOC emissions and destruction of these emissions in an add-on device such as an incinerator. In some cases use of alternative low solvent or solventless coatings can also be used to meet these limits.

6.4 ALTERNATIVE CONTROL METHODS

In this section are briefly discussed methods of low solvent and solventless systems, which have been demonstrated to be applicable to some fabric coating products, and the two principal add-on systems, incineration and carbon adsorption, generally used for emission control. This information has been extracted principally from the previously cited EPA report, Control of Volatile Organic Emissions from Existing Stationary Sources, Volumes I and II, which should be consulted for a more thorough discussion. In some instances, additional comment was obtained from coaters, coating material suppliers and control equipment manufacturers.

6.4.1 Low Solvent and Solventless Coatings

Organic emissions can be reduced 80 to 100 percent through use of coatings which inherently have low levels of organic solvents. Both high-solids and waterborne coatings are used. The actual reduction achievable depends on the organic solvent contents of the original coating and the new one. Using a coating which has a low organic solvent content may preclude the need for an emission control device. Often the coating equipment and procedures need not be changed when a plant converts to coatings low in organic solvent.

Although a number of companies have converted to low solvent coating, either in part or in total, one may not presume them to be universally applicable. Each coating line is somewhat unique and many coated fabrics have different specifications.

None of the three plants identified were aware of suitable alternative coatings now available which would meet the quality and performance standards required in all of their products. Ford Motor Company is planning to use a water-based slip coating in part of its product line but believes that additional research and development is required before water-based coatings or other types of coatings, such as radiation cured coatings, adaptable to all of their products would be available. The other two firms indicated that an add-on control device was probably the only acceptable method of compliance at this time or in the near future.

6.4.2 Incineration

Catalytic and direct thermal incineration processes convert hydrocarbons to carbon dioxide and water at high temperatures. Incineration is widely accepted as a reliable means of reducing hydrocarbon emissions by 90 percent or more.

Generally, the major disadvantage of this approach is the increased energy required to raise the exhaust gas temperatures over 1,200°F for direct incineration and 700°F for catalytic incineration. Natural gas is the most commonly used fuel though propane, fuel oils, or other fluid hydrocarbons can be employed. Fuel oil is not generally acceptable because of the sulfur oxides generated in combustion or the presence of catalyst poisons in the oil. Another problem is the generation of nitrogen oxides in direct fired incinerators resulting from the exposure of air to high-temperature flames.

The increased energy consumption can, in some cases, be reduced or eliminated by heat exchange of the exhaust gases with fresh emissions (primary heat recovery) or by use of the hot exhaust gases in process applications (secondary heat recovery). Typical use of secondary heat recovery is for oven heat in drying or curing ovens. In fact, with efficient primary exchange and secondary heat recovery, total fuel consumption of an incinerator-oven system can be less than that for the oven before the incinerator is added. The heat required to sustain the system comes from combustion of volatile organic compounds in the exhausts.

Both catalytic and direct fired systems are capable of high heat recovery efficiency if several conditions occur:

- VOC concentrations are or can be increased to 8-10 percent or more of their LEL (lower explosion limit).
- Oven temperatures are sufficiently high to enable use of the sensible heat in the exhaust gases after primary heat exchange. Usually, oven temperatures above 140°F are sufficient to allow 85 percent or more overall heat recovery.
- Where catalytic incinerators are used, no compounds must be present in the gases treated which could poison or blind the catalyst.

In most coating operations, drying and curing temperatures are 250°F or higher. By reduction of air flow to reach exhaust levels of 8-10 percent or higher and proper design of the heat recovery system, it may be possible to achieve overall heat recoveries of 85 percent or greater. For purposes of cost estimation it was assumed that such heat recovery efficiency could be reached.

6.4.3 Carbon Adsorption

Carbon adsorption has been used since the 1930s for collecting solvents emitted from paper coating operations. Most operational systems on coating lines were installed because they were profitable. Pollution control has usually been a minor concern. Carbon adsorption systems on coating lines range in size from a few thousand to tens of thousands of cubic feet per minute. Exhausts from several coating lines are often manifolded together to permit one carbon adsorption unit to serve several coating lines.

The greatest obstacle to the economical use of carbon adsorption is that, in some cases, reusing solvent may be difficult. In many coating formulations, a mixture of several solvents is needed to attain the desired solvency and evaporation rates. If this solvent mixture is recovered, it sometimes cannot be reused in formulating new batches of coatings. Also if different coating lines within the plant use different solvents and are all ducted to one carbon adsorption system, then there may be difficulty reusing the collected solvent mixture. In this case, solvents must be separated by distillation.

However, in some cases azeotropic, constant boiling mixtures can occur which can be separated only by specialized techniques. Most coating firms would not have the skills necessary for the complex distillation and separation procedures needed. For small adsorption systems, the additional separation expenses would probably exceed the cost of fresh solvent.

Also, adsorption of solvents containing water soluble compounds (such as alcohols, ketones or esters) can present a secondary pollution problem where steam is used for bed regeneration. Additional treatment of the condensed steam with its content of dissolved organics would be required, increasing the complexity of the solvent recovery system and its cost.

6.5 COST AND VOC REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

This section discusses the projected costs of control for fabric coating in the state, based on the emission inventory developed by the Michigan Department of Natural Resources and information developed by EPA sources. Where possible, the validity of the costs were confirmed with coating firms and equipment manufacturers.

As discussed earlier in this report, only three major coaters were identified, with the Ford Motor Company being the largest by far. The major impact of the regulation will be upon this plant, though the other two plants, Rospatch Label Division and St. Clair Rubber Company, will be significantly affected. All three companies were interviewed to determine their views on methods and possible costs of compliance. The Ford Motor Company was particularly cooperative and has supplied much useful data and comment; most of the discussion, which follows, is based on this information.

6.5.1 Costs of Alternative Control Systems

Exhibits 6-9 and 6-10, following page 6-19, summarize costs for typical incineration systems using primary heat and secondary heat exchange. These curves and other cost information obtained from Control of Volatile Organic Emissions from Existing Stationary Sources, Volume I (EPA-450/2-76-028) were used, as discussed in the next section, to estimate compliance costs for the three firms believed to be affected. It is assumed that current exhaust flow rates can be reduced sufficiently to attain 25 percent of LEL (lower explosion limit). This is possible with well-designed capture systems in most cases, as discussed in previous EPA guideline reports such as Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-77-008). Exceptions may occur where product drying times or other coating characteristics may not permit such operation. However, this assumption and the use of secondary heat recovery appear to be achievable for the three firms considered to be affected.

As discussed in section 6.3.4 and shown in Exhibit 6-3 of this report, total current emissions are about 3,000 tons per year. The Ford Motor Company has indicated that they have planned to install an incinerator on one coating line and to convert another to use water-based materials. They expect an emission reduction of 718 tons per year once these two changes have been made. Costs, therefore, are based only on the remaining total of 2,300 tons per year of emissions.

The major problem in estimating individual installed costs of control systems is the added cost of installation. The EPA estimates were made on the assumption of an easily retrofitted system. In practice, coaters and equipment manufacturers have found actual installed costs to be three to five times those summarized in Exhibit 6-9 and 6-10. For instance, E.I. DuPont de Nemours, based on their experience on actual installed equipment, estimates[1] $1.2 million for a carbon adsorber to treat 15,000 scfm of exhaust gases. Recent prices from recuperative type incinerator manufacturers for a 15,000 scfm direct fired, ceramic bed primary recuperative heat exchanger are about $150,000 for the incinerator alone. Installed costs, with provision for return of exhausts for secondary heat recovery, are estimated at more than $300,000. The estimates in Exhibits 6-9 and 6-10 indicated costs of $320,000 for an equivalent adsorber, and $140,000 for the incinerator.

6.5.2 Estimated Compliance Costs

As discussed above, emissions considered to be applicable under RACT for fabric coating are about 2,300 tons per year, of which about 2,000 tons per year will be due to coating operations at the Ford plant. Based on the EPA cost data presented in Exhibit 6-9 and 6-10, the minimum capital costs for compliance are estimated to be about $1,600,000. This assumes that retrofit will involve minimal difficulty, that air flow can be reduced sufficiently to allow oven operation at 25 percent of LEL and that direct fired incinerators would be used. Other assumptions used in this estimate are summarized in Exhibit 6-11, following Exhibit 6-10.

Because capital and operating costs are sensitive to economies of scale, individual incinerator sizes were chosen assuming that one incinerator per coating line would be used at each of the plants affected as a minimum.

However, because of the anticipated retrofit factors (such as the additional costs for enclosing coating ovens, requirements for temporary removal or shutdown of equipment, roof mounting of the incinerators, addition of new fuel supply systems), the total capital costs are expected to be about three to four times the figures given previously or about $4.8 million to $6.4 million and will be distributed as shown in Exhibit 6-12, following Exhibit 6-11. These are expected to take into account retrofit costs as well as inflation increased costs since the EPA report was published.

---

[1] T.A. Kittleman and A.B. Akell, "The Cost of Controlling Organic Emissions," Chemical Engineering Process, April 1978.

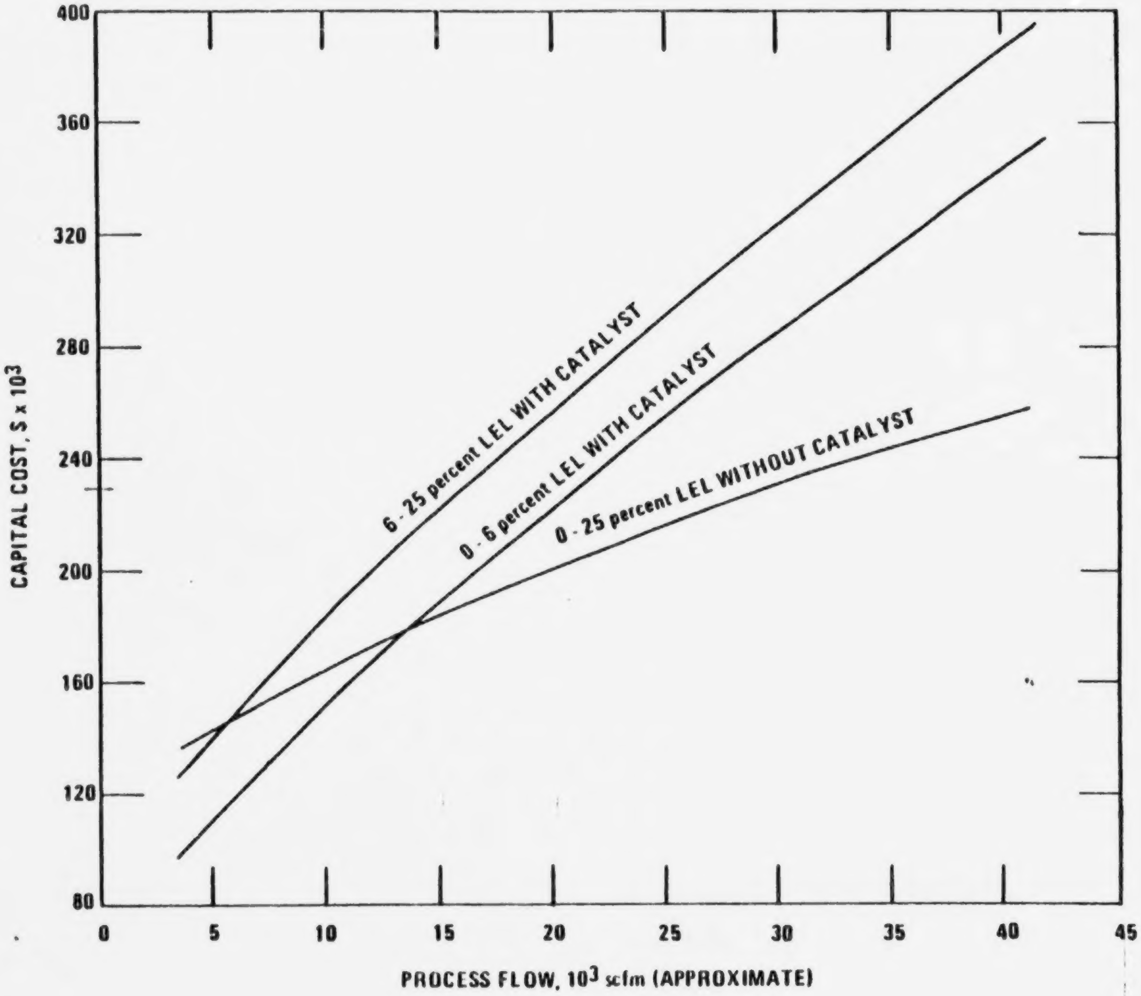
Annualized costs are estimated to be about $1.3 million to $1.7 million for the three firms as shown in Exhibit 6-12. The estimate of operating costs is very sensitive to the estimated capital costs and the degree of heat recovery which can be achieved. Normally, capital charges for depreciation, taxes, adminstrative costs, maintenance and interest would be about 25 percent of capital; in this case, minimum capital charges would be $1.2 million to $1.6 million. Normally, large full requirements for direct fired incineration are partially offset by the use of secondary heat recovery.

Ford personnel have estimated total capital to meet the proposed regulation at $7.4 million; St. Clair at about $1 million. Based on the estimates by these two companies, total expenditures would be $7.0 million to $9.3 million. Both cost estimates are subject to the basic assumptions used, the most critical being the level of LEL which can be achieved and the period over which emissions occur; both determine the operating air flow rates which are the major determinant of cost.

EXHIBIT 6-9

U.S. Environmental Protection Agency

CAPITAL COST FOR DIRECT FLAME AND CATALYTIC INCINERATORS WITH PRIMARY AND SECONDARY HEAT EXCHANGE

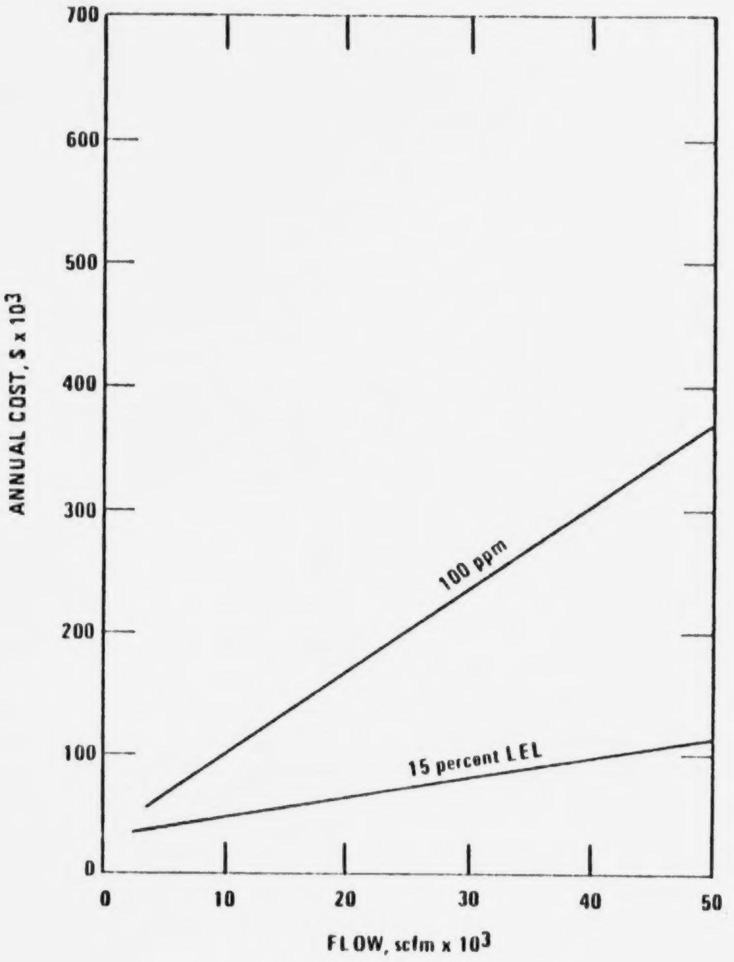


Sou : ntr of lat O nic nis ns om st St on
Sources, Volume II (EPA-450/2-76-028)

EXHIBIT 6-10

U.S. Environmental Protection Agency

ANNUAL COST OF DIRECT FLAME INCINERATORS
(Primary and secondary heat recovery)



Source: *Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II* (EPA-450/2-76-028)

EXHIBIT 6-11
U.S. Environmental Protection Agency
SUMMARY OF ASSUMPTIONS USED IN COST ESTIMATE

Assumptions

90 percent of emissions are controlled by incineration with primary and secondary heat recovery; 90 percent of solvent emissions from the coating line are collected.

25 percent LEL is equal to 3,000 ppm of methyl ethyl ketone by volume.

Air flow can be reduced to reach 25 percent LEL

Emission rate is constant over a period of 5,840 hours per year.

Other assumptions regarding incinerator and adsorber prices, as estimated in Control of Volatile Organic Emissions from Existing Stationary Sources, Vol. I: Control Methods for Surface-Coating Operations, EPA-450/2-76-028, are valid. Utility and labor costs are escalated to account for inflation to 1977.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 6-12
U.S. Environmental Protection Agency
ESTIMATED COSTS OF COMPLIANCE FOR THREE PLANTS IDENTIFIED
($ millions)

Plant	Estimated Capital Costs for Direct Fired Incineration
Ford Motor Company	3.9-5.2
Rospatch Label Company	0.39-0.52
St. Clair Rubber Company	0.48-0.64
	4.77-6.36

Source: Booz, Allen & Hamilton Inc.

6.6 DIRECT ECONOMIC IMPACTS

This section presents the direct economic implications of implementing the RACT guidelines for surface coating of fabrics on a statewide basis. The analysis includes the availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost pass-through), state economic variables and capital investment.

6.6.1 RACT Timing

Current proposed guidelines for fabric coating suggest several compliance deadlines for alternative methods of compliance.[1] Generally, for add-on systems they call for installation of equipment and demonstration by mid-1980 or late 1980; for low solvent systems, by late 1980 or mid-1981, depending upon the degree of research and development needed. Major coaters, material suppliers and equipment manufacturers believe these deadlines to be unattainable.

- Normally, large incinerator and carbon adsorption systems will require about a year or more from receipt of purchase to install and start up the system. Engineering may require three months or more, fabrication three to six months and installation and startup as long as three months. A major paper coater with considerable experience with similar installations estimates that the complete cycle of installation, from initial selection of control method to testing of the system, would required 37 months plus an initial 12 months to establish an economically sound method of control.

- Only a small number of companies manufacture incineration systems with proven high heat recovery. The cumulative effect of equipment requirements by all firms in the U.S. needing control devices could severely impede the ability of these firms to supply equipment. In some cases, the most efficient devices are only now undergoing initial trials, and no production capacity has been developed. Generally incinerator firms require about one year after order to supply units where engineered systems with minimum heat requirements are to be installed.

---

[1] Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001.

- A major coating firm estimates that the use of low solvent or solventless coatings may take as long as 68 months from initial research, through product evaluation and customer acceptance to final production. Product and process development alone may take as long as 24 months and product evaluation over 14 months.

In general, it appears that if either add-on control systems are used or new low solvent systems need to be developed, deadlines need to be extended.

The Ford Motor Company estimates that, to maintain business and minimize unemployment, a continuous conversion program with add-on devices installed at a rate of about two per 15 months after initial approval and design would require a period of about 8 years. Three years would be required for project approval, design engineering and equipment fabrication and delivery.

6.6.2 Technical Feasibility Issues

As discussed above, low solvent or solventless materials are used in many coating operations. At present, however, many types of solvent-based systems have no satisfactory replacement. The alternative materials do not meet the product quality standards demanded by the coaters. Additional development is needed and will require the combined efforts of both the coaters (who must maintain product quality) and the coating material suppliers. Ideally, the new coating materials should be adaptable to existing coating equipment to minimize additional capital investment.

As discussed above, both incineration and carbon adsorption are not completely satisfactory add-on control systems. Incineration requires large volumes of additional fuel if good heat recovery is not achieved; carbon adsorption is not usable on many coating systems because of the multiplicity of compounds used in solvent mixtures.

6.6.3 Comparison of Costs with Selected Economic Indicators

The net increase in the annualized costs to coaters cannot be estimated with a high degree of confidence since operating costs are highly sensitive to various retrofit situations, the efficiency of heat recovery and other factors, as discussed above. Based on the estimated annual costs of about $1.25 million as presented in Exhibit 6-12, and the estimated value of shipments of the three firms, annual compliance costs would be about 1 percent of the value of shipments. In a recent report,[1] increased costs for control of emissions from a rubber coating line using incineration with primary heat recovery were estimated to be about 0.9 percent of the price of the finished rubberized fabric.

The major economic impact in terms of cost to individual companies will probably be capital related rather than from the increased annualized costs. The capital required for RACT compliance will present a significant amount of capital appropriations for all companies affected. For the three companies, compliance requirements for add-on systems, which appear to be the only practical method of meeting proposed guidelines, would equal or exceed their current level of capital expenditures for plant improvement and expansion.

Though the capital investment required will not seriously affect the Ford plant, the other two plants may encounter difficulty in justifying or securing the capital funds required. Both are divisions of small firms. Rospatch Label Company is a division of the Rospatch Corporation, for which total annual sales are about $36 million; the St. Clair Rubber plant is owned by the St. Clair Rubber Company, for which annual sales are about $10 million.

---

[1] Springborn Laboratories, Inc., op.cit.

6.6.4 Selected Secondary Economic Impacts

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

Total employment is expected to be marginally affected since about 1,600 workers are employed by the three firms identified. The Ford plant, which employs about 1,300 of these, is not expected to cease operation despite the increased costs of compliance; though there may be temporary layoffs during temporary line shutdowns for equipment revision. It is uncertain, at this time, whether the two smaller firms would consider closing down their coating operations. In any case, 300-400 workers in total would be involved. All three plants might add a few additional workers to operate and maintain the add-on control devices.

There would be no change in the market structure within the state since the firms identified are in different markets and have different product lines.

Productivity is not expected to be affected except for a short period when lines must be shut down for modifications or installation of equipment.

* * * *

Exhibit 6-13, on the following page, summarizes the conclusions and projected implications of the results from this study.

EXHIBIT 6-13

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR FABRIC COATERS IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	Three firms were identified as being affected by the proposed regulation
Indication of relative importance of industrial section to state economy	Total value of shipments by the three plants identified is about $100 million. These plants employ about 1,600 persons
Current industry technology trends	Newer plants are built with integrated coating and emission control systems; older plants such as those expected to be affected in Michigan, are only marginally competitive now
1977 VOC emissions (actual)	Current emissions are estimated at about 3,000 tons/year
Industry preferred method of VOC control to meet RACT guidelines	Direct fired incineration for short range, low solvent coatings are a long range goal
Assumed method of VOC control to meet RACT guidelines	Direct fired incineration with primary and secondary heat recovery

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	Study team estimate is about $4.8-6.4 million. Companies affected estimate costs to be as much as $10 million
Annualized cost (statewide)	Approximately $1.3 million to $1.7 million which represents 1 percent of the industry's 1977 statewide value of shipments
Price	Assuming a "direct pass-through of costs" prices of coated fabrics will increase by about 1 percent
Energy	Assuming 70 percent heat recovery about 14,000 equivalent barrels of additional fuel oil would be required per year
Productivity	No major impact
Employment	No major impact
Market Structure	No change in market structure within the state is anticipated; firms affected have different product lines
RACT timing requirements (1982)	Plants may have problem in control equipment deliveries
Problem areas	Additional capital and operating costs may make the plants uncompetitive with more modern and efficient ones Capital and operating costs can only be approximated because of unknown retrofit situations
VOC emissions after RACT control	450 tons/year (19 percent of 1977 VOC emissions) RACT will account for a total of about 1,900 tons/year reduction
Cost effectiveness of RACT control	$650 annualized cost/annual ton of VOC reduction

Note: Cost data is based on emission information supplied by the Michigan Department of Natural Resources.

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Davidson's Textile Blue Book, 1977.

T.W. Hughes, et al., *Source Assessment: Prioritization of Air Pollution from Industrial Surface Coating Operations*, Monsanto Research Corporation, Dayton, Ohio. Prepared for U.S. Environmental Protection Agency, Research Triangle Park, N.C., under Contract No. 68-02-1320 (Tech. 14) Publication No. 650/2-75-019a.

T.A. Kittleman and A.B. Akell, "The Cost of Controlling Organic Emissions," *Chemical Engineering Progress*, April 1978.

Springborn Laboratories, *Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report*, EPA Contract No. 68-02-2075, August 23, 1977.

Textile Economics Bureau, *Technicon*, November 1977, State Industrial Directories Corporation, *1978-79 Michigan State Industrial Directory*, October 1978.

Thomas Register of American Manufacturers, 1978.

U.S. Department of Commerce, *County Business Patterns*, Illinois, 1976.

U.S. Department of Commerce, *Annual Survey of Manufactures, 1976*, *Industry Profiles*, M76(AS)-7

U.S. Department of Commerce, *Annual Survey of Manufactures, 1976*, *Value of Product Shipments*, M76(AS)-2

U.S. Environmental Protection Agency, *Control of Volatile Organic Emissions from Existing Stationary Sources, Volume I*, EPA-450/2-76-028, May 1977.

U.S. Environmental Protection Agency, *Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II*, EPA-450/2-77-008, May 1977.

U.S. Environmental Protection Agency, *Regulatory Guidance for Control of Volatile Organic Compounds Emissions from 15 Categories of Stationary Sources*, EPA-950/2-78-001, April 1978.

Private conversations with:

- Canvas Products Association International, St. Paul, Minnesota
- Overly, Inc., Neenah, Wisconsin
- Textile Economics Institute, New York City, New York
- TEK Systems, DePere, Wisconsin
- Joanna Western Mills, Chicago, Illinois
- Western Acadia, Chicago, Illinois
- Bobst Champlain, Roseland, New Jersey
- REECO, Inc., Morris Plains, New Jersey
- Ford Motor Company, Dearborn, Michigan
- St. Clair Rubber Company, Marysville, Michigan
- Rospatch Label Company, Rospatch, Michigan
- Cadillac Rubber and Plastics, Cadillac, Michigan
- Textile Industries, Detroit, Michigan
- Flexoid, Hazel Park, Michigan
- Wayne Gasket, Mt. Clemens, Michigan

9.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SURFACE COATING FOR INSULATION OF MAGNET WIRE IN THE STATE OF MICHIGAN

9.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SURFACE COATING FOR INSULATION OF MAGNET WIRE IN THE STATE OF MICHIGAN

This chapter presents a detailed analysis of the impact of implementing RACT for surface coating for insulation of magnet wire in the State of Michigan. The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Emissions and current controls
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of the application of surface coatings for magnet wire, interviews and analysis.

9.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impacts

for the surface coating for insulation of magnet wire in Michigan.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

9.1.1 Industry Statistics

The magnet wire sector of the nonferrous wire industry is part of the Standard Industrial Classification (SIC) 3357, Drawing and Insulating of Nonferrous Wire.

Current Industrial Reports provided detailed industry statistical data for the magnet wire sector of the nonferrous wire industry, only on a national basis, for 1976. Individual state data on value of shipments appear in the 1972 *Census of Manufactures*. Therefore, our methodology to provide statewide statistical data for 1977 was as follows:

- Calculate the percent of U.S. value of shipments of magnet wire for 1972 for the East North Central Region.
- Determine the percent of East North Central Region value of shipments of magnet wire for individual states.
- Apply the above-mentioned percentages to the 1976 U.S. value of shipments for magnet wire.
- Adjust 1976 figures to 1977 levels.
- Some of the manufacturers were interviewed to validate the list of potentially affected facilities.
- Secondary source data were collected from sources such as:
    - *Sales and Marketing Management* (April 25, 1978)
    - *Census of Manufactures* (1972)
    - *Annual Survey of Manufactures* (1976).

- The Booz, Allen study team, utilizing all available inputs, including interviews with selected manufacturers, determined an estimated percent of total U.S. value of shipments applicable to the state for the magnet wire sector of SIC 3357.

Data on the total number of pounds of copper and aluminum wire were available for the state, but no information was available on the number of pounds or feet of wire coated as a function of wire size and product classification.

9.1.2 VOC Emissions

Booz, Allen developed a list of four facilities, identified as hydrocarbon emitters in the surface coating for insulation of magnet wire, covered by RACT in the State of Michigan. This listing of industries subject to RACT guidelines for hydrocarbon emissions is based on information provided by the 1977 Michigan Air Pollution Reporting form instructions. The list, therefore, may not be all inclusive, or it may include some industries that may not be actually performing the coating operations indicated or identified by the RACT category. Sufficient data and resources were not available to verify each listing. Only those facilities with greater than two tons per year total emission for 1977, are included.

Two of the four listed facilities have implemented emission control devices in all of their ovens. However, there has been no verification to date that these facilities meet the new RACT guidelines. For the purposes of this study, we will assume these facilities meet the RACT guidelines.

9.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emission in the surface coating for insulation of magnet wire are described in Control of Volatile Organic Emissions from Existing Stationary Sources--Volume IV: Surface Coating for Insulation of Magnet Wire (EPA-450/2-77-033, December 1977).

9.1.4 Cost of Control of VOC Emissions

The costs of control of volatile organic emissions in the surface coating for insulation of magnet wire were developed by:

- Determining the alternative types of control systems likely to be used

- Estimating the probable use of each type of control system

- Defining system components
- Developing installed capital costs for each alternative control system
- Defining a model plant
- Developing costs of a control system for the model plant:
  - Installed capital cost
  - Direct operating cost
  - Annual capital charges
  - Energy requirements
- Extrapolating model costs to individual industry sectors
- Aggregating costs to the total industry for the state.

The model used for developing costs of control to meet the RACT guidelines assumed that the affected facilities required catalytic incineration with primary heat recovery. Because detailed information on the specific coating lines was not available from all potentially affected magnet wire coaters, the study team estimated the number of coating lines in Michigan from emission data and line characterizations that were available from the Illinois EPA. It was assumed (from Illinois EPA data) that high temperature ovens emitted approximately 13 tons per year per oven. Based on this assumption, the number of ovens and the associated cost of control for companies operating high temperature ovens were estimated in the state of Michigan from the total VOC emissions.

9.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements to implement RACT, assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Michigan.

9.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating for insulation of magnet wire in Michigan. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that are published for the base year), "B" indicates data that were extrapolated from hard data and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 9-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 9-1
U.S. Environmental Protection Agency
SURFACE COATING OF MAGNET WIRE
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		X	
Emissions	X		
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

9.2 INDUSTRY STATISTICS

Industry statistics and business trends, for the manufacture and surface coating for insulation of magnet wire in Michigan, are presented in this section. The discussion includes a description of the number of facilities, a comparison of the size of the magnet wire industry to the state economic indicators, a historical characterization of the industry and an assessment of future industry patterns. Data in this section form the basis for assessing the impact on this industry of implementing RACT to VOC emissions in Michigan.

9.2.1 Size of the Industry

Information from Michigan Air Pollution Reporting forms and Booz, Allen interviews identified four facilities participating in the surface coating for insulation of magnet wire, as shown in Exhibit 9-2, on the following page. These companies accounted for approximately $16 million in shipments in 1977. The estimated number of employees in 1977 was between 500 and 1,000. The data and sources of information are summarized in Exhibit 9-3, following Exhibit 9-2, and indicate that Michigan shipped an estimated 2.1 percent of the U.S. value of shipments of copper wire and 3.1 percent of U.S. value of shipments of aluminum wire.

9.2.2 Comparison of the Industry to the State Economy

A comparison of the value of shipments of magnet wire with the state economy indicates that the magnet wire industry represents between 0.017 percent and 0.018 percent of the total Michigan value of shipments of all manufactured goods. The industry employs between 0.05 percent and 0.09 percent of all people employed in manufacturing in Michigan. These figures are shown in Exhibit 9-4, following Exhibit 9-3, along with the sources of the data.

9.2.3 Historical and Future Patterns of the Industry

The shipments of magnet wire have generally followed the economic condition of the country. Since 1967, sales have generally increased annually, except during the recession in 1974 and 1975.

Shipments picked up in 1976 and continued to grow in 1977. The outlook through 1985 is a continued annual growth of about 5 percent.

Since 90 percent of the wire coated is copper, the value of shipments of the wire product will vary with the fluctuating supply and demand picture in the copper industry. Historical and future patterns are shown in Exhibits 9-5 and 9-6, following Exhibit 9-4.

EXHIBIT 9-2

U.S. Environmental Protection Agency

LIST OF MANUFACTURERS, POTENTIALLY AFFECTED BY RACT GUIDELINES, WHO SURFACE COAT MAGNET WIRE IN MICHIGAN

Facility Name	Location
Anaconda Wire and Cable Co.	Muskegon
Cass Wire Company	Cassopolis
Essex International Magnet Wire Division	Hillsdale
Prestolite Wire Division Eltra Corporation	Port Huron

Source: Michigan Air Pollution Reporting forms and Booz, Allen & Hamilton Inc. analysis

EXHIBIT 9-3
U.S. Environmental Protection Agency
INDUSTRY STATISTICS--SURFACE COATING
FOR INSULATION OF MAGNET WIRE
MICHIGAN

SIC Code	RACT Category	1977 U.S. Totals		1977 Michigan Totals		
		Estimated Quantity Shipped (millions lbs.)	Estimated Value of Shipments ($ million)	Estimated Quantity Shipped (million lbs.)	Estimated Value of Shipments ($ million)	Estimated Percent of U.S. Shipments
3357	Magnet wire					
	Copper	520	720	11	13	2.1
	Aluminum	65	110	2	3	3.1

Source: Current Industrial Reports, Insulated Wire and Cable, 1976 (issued July 1977); 1972 Census of Manufactures, Nonferrous Metal Mills and Miscellaneous Primary Metal Products (issued March 1975 and updated to 1977); Booz, Allen & Hamilton Inc.

EXHIBIT 9-4
U.S. Environmental Protection Agency
COMPARISON OF MAGNET WIRE STATISTICS WITH STATE OF MICHIGAN ECONOMIC DATA

	Estimated Michigan Economic Indicators	Estimated Percent of Michigan Manufacturing Economy Engaged in Magnet Wire Manufacturing
Total 1977 Value of Shipment of all manufactured goods	$ 87-91 billion	0.017-0.018
Number of employees in manufacturing	1.0-1.2 million	0.05-0.09

Source: Current Industrial Reports, Insulated Wire and Cable, 1976 (issued July 1977); 1972 Census of Manufactures, Nonferrous Metal Mills and Miscellaneous Primary Metal Products (issued March 1975 and updated to 1977); Sales and Marketing Management, April 25, 1977; Annual Survey of Manufacturers, Statistics for States, Standard Metropolitan Statistical Areas, Large Industrial Countries and Selected Areas, 1976; Booz, Allen & Hamilton Inc.

EXHIBIT 9-5
U.S. Environmental Protection Agency
HISTORICAL U.S. SHIPMENT
FIGURES--MAGNET WIRE INDUSTRY

	1967	1972	1973	1974	1975	1976	1977
Value of Shipments[a] ($ million)	420	516	648	748	461	650	830
Quantity Shipped:[a]							
Copper (million lbs.)	424	445	537	446	338	467	520
Aluminum[b] (million lbs.)	47	49	59	49	37	58[c]	57[c]

---

a. Current Industrial Reports, Insulated Wire and Cable, 1976 (issued July 1977); U.S. Industrial Outlook 1977; U.S. Industrial Outlook 1978; Predicasts, No. 64 (July 27, 1976); 1972 Census of Manufactures, Nonferrous Metal Mills and Miscellaneous Primary Metal Products (issued March 1975).

b. Numbers represent an average of 10 percent of total quantity shipped per year as per Current Industrial Reports, Insulated Wire and Cable, 1976 (issued July 1977)

c. Numbers reported in data sources listed in footnote a. above.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 9-6

U.S. Environmental Protection Agency

U.S. SHIPMENTS FORECAST FOR MAGNET WIRE INDUSTRY

	1978	1985
Value of Shipments[a] ($ million)	970	1,820
Quantity shipped (million lbs.)[a]		
Copper	540	720
Aluminum	60	80

---

a. *U.S. Industrial Outlook*, 1977

Source: Booz, Allen & Hamilton Inc.

9.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents the process description for the preparation, application and curing of surface coatings for insulation of magnet wire.

9.3.1 Process Description of Surface Coating for Insulation of Magnet Wire

Magnet wire coating is the process of applying a coating of electrically insulating varnish or enamel to aluminum or copper wire for use in electrical machinery. The wire is called magnet wire because this wire carries an electrical current which creates an electromagnetic field, in such equipment as electrical motors, generators and transformers. The wire coating must meet rigid specifications of electrical, thermal and abrasion resistance.

Magnet wire is usually coated in large plants which both draw and insulate the wire. The wire is unwound from spools and passed through an annealing furnace. Annealing softens the wire to make it more pliable for its trip over the pulley network and also acts as a cleaning chamber to burn off oil and dirt left from previous operations.

Exhibit 9-7 and Exhibit 9-8, on the following pages, describe and illustrate the pretreatment, coating and curing processes for a typical magnet wire coating facility.

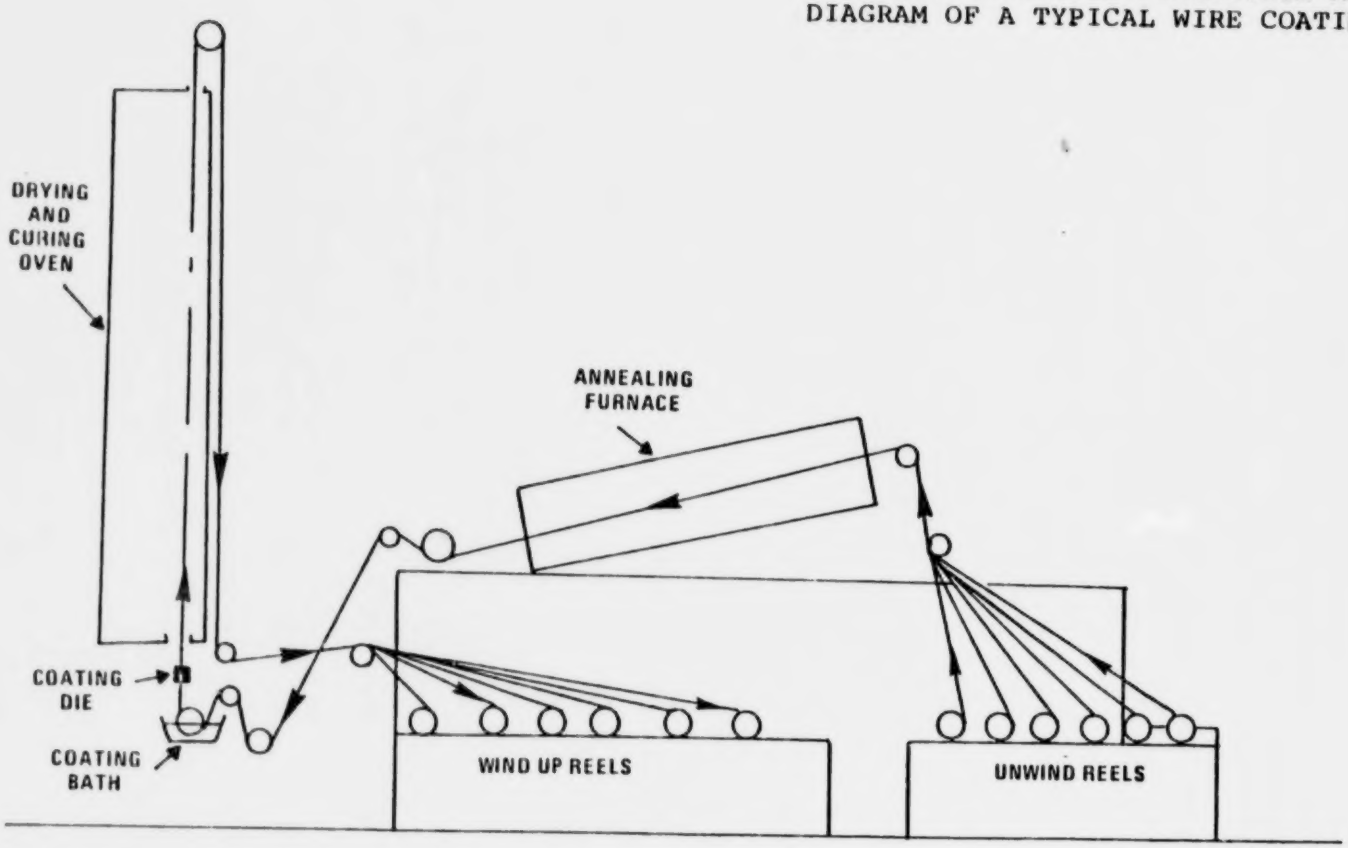
EXHIBIT 9-7
U.S. Environmental Progection Agency
DESCRIPTION OF PRESENT MANUFACTURING TECHNOLOGY FOR MAGNET WIRE

Manufacturing Process Description	Coating Process Description	Curing Process Description	Common Coating Solvents
Prior to coating: Wire is unwound from spools Passed through an annealing furnace	Wire passes through a bath of coating Wire is drawn vertically through an orifice or coating die Die scrapes off excess coating Wire passes through the oven and coating is cured It again passes through the coating application curing cycle, from 4 to 12 times	Wire is dried and cured in a two zone oven: Drying zone at 200°C Curing zone at 430°C	Cresylic acid Xylene Alcohols Cresols, meta para Diacetone alcohol Hi-Flash naptha Methyl ethyl ketone N-methyl pyrrolidine Ortho cresol Phenol Toluene

Source: Control of Volatile Organic Emissions from Existing Stationary Sources--Volume IV: Surface Coating for Insulation of Magnet Wire; EPA-450/2-77-033, December 1977.

EXHIBIT 9-8

U.S. Environmental Protection Agency
DIAGRAM OF A TYPICAL WIRE COATING LINE


DRYING AND CURING OVEN
ANNEALING FURNACE
COATING DIE
COATING BATH
WIND UP REELS
UNWIND REELS

Source: Control of Volatile Organic Emissions from Existing Stationary Sources--Volume IV: Surface Coating for Insulation of Magnetic Wire, EPA-450/2-79-033, December 1977.

9.4. EMISSIONS AND CURRENT CONTROLS

This section presents information on the distribution of VOC emissions during the coating operation, the estimated VOC emissions in Michigan in 1977 and the current level of emission control implemented in the state.

VOC emissions occur in two areas during the process of coating magnet wire. They are the coater and oven areas. The percent distribution of VOC emissions by area is as follows:

Estimated Fraction of Emissions from Coater Area	Estimated Fraction of Emissions from Oven Area
< 10%	> 90%

Exhibit 9-9, on the following page, shows the total estimated emissions in tons per year from coaters of magnet wire in Michigan. The estimated emissions in Michigan from four magnet wire coating facilities are 465 tons per year. Since Cass Wire and Essex Wire have already implemented afterburners on all their ovens prior to initiation of RACT guidelines, the actual emissions subject to RACT control are 242 tons.

9.4.1. RACT Guidelines

The RACT guidelines for control of VOC emissions from the surface coating of magnet wire require the following:

- Use of high solids (at least 77 percent by volume); or powder coating; or hot melt; or waterborne coating which contains 29 volume percent solids, 8 volume percent organic solvent and 63 volume percent water
- Use of add-on control devices, such as incinerators or carbon adsorbers.

Exhibits 9-10, 9-11 and 9-12, following Exhibit 9-9, summarize the RACT emission limitations and control options for VOC emissions control for surface coating for insulation of magnet wire.

EXHIBIT 9-9
U.S. Environmental Protection Agency
RACT DATA SUMMARY OF ESTIMATED VOC EMISSIONS FOR SURFACE COATERS FOR INSULATION OF MAGNET WIRE IN MICHIGAN

Facility Name	Current Average Hydrocarbon Emissions (Ton/Year)	Potential Control Efficiency with RACT (Percent)	Potential Emission Reduction with RACT (Ton/Year)
Anaconda Wire and Cable	144	95	136
Cass Wire Co.	30	--	--
Essex Wire	158	--	--
Prestolite Wire Div. (Eltra Corp.)	133	80	106
Total	465		242

Source: Booz, Allen and Hamilton Inc. analysis of Michigan State Emission Inventory

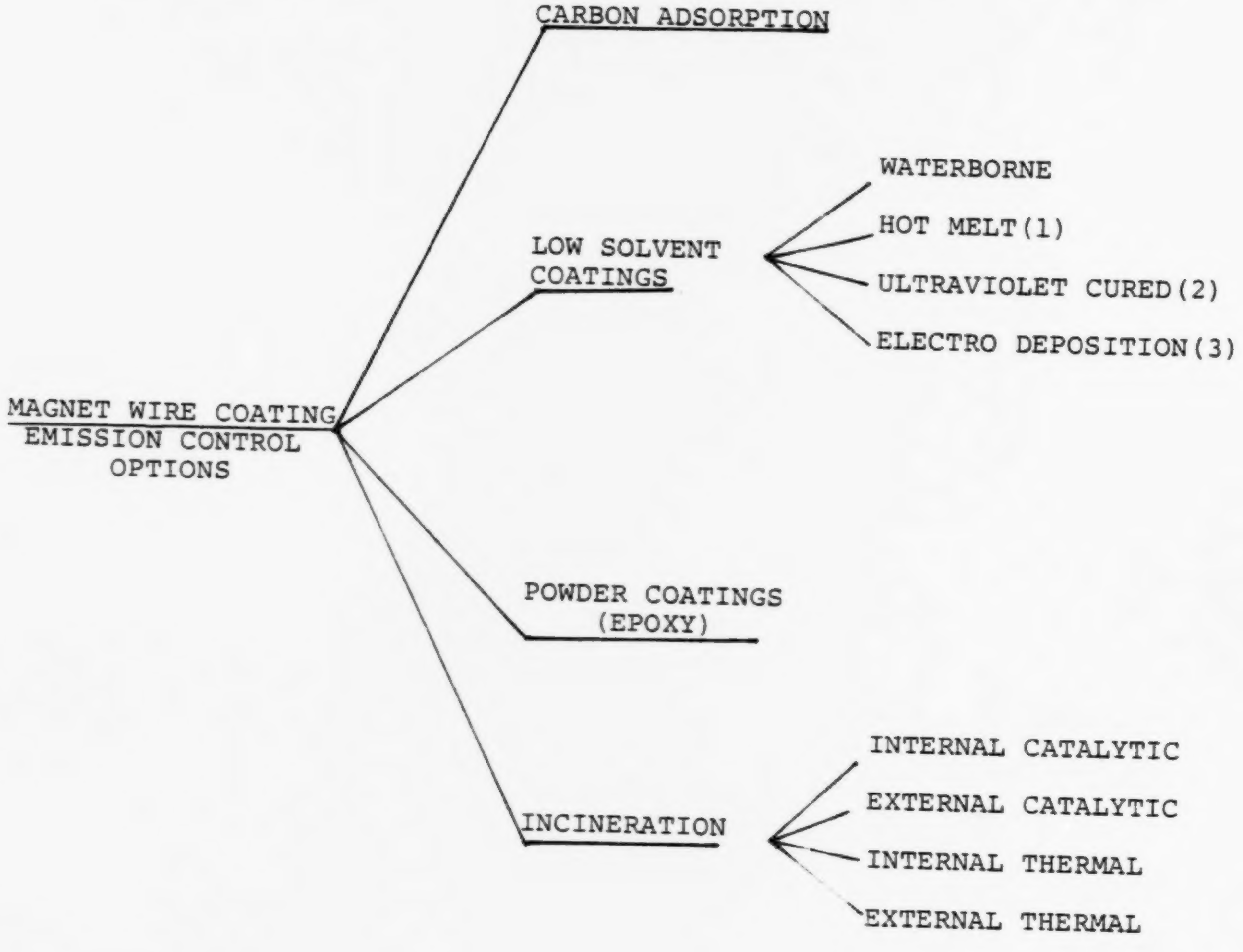
EXHIBIT 9-10

U.S. Environmental Protection Agency EMISSION LIMITATIONS FOR RACT IN THE SURFACE COATING FOR INSULATION OF MAGNET WIRE

	Recommended Limitations For Low Solvent Coatings	
Affected Facility	kg solvent per liter of coating (minus water)	lbs. solvent per gallon of coating (minus water)
Wire coating oven	0.20	1.7

Source: Control of Volatile Organic Emissions from Existing Stationary Sources--Volume IV: Surface Coating for Insulation of Magnetic Wire, EPA-450/2-77-033, December 1977.

EXHIBIT 9-11
U.S. Environmental Protection Agency
SUMMARY OF APPLICABLE CONTROL TECHNOLOGY FOR CONTROL OF ORGANIC EMISSION FROM THE SURFACE COATING FOR INSULATION OF MAGNET WIRE


MAGNET WIRE COATING EMISSION CONTROL OPTIONS
CARBON ADSORPTION
LOW SOLVENT COATINGS
WATERBORNE
HOT MELT(1)
ULTRAVIOLET CURED(2)
ELECTRO DEPOSITION(3)
POWDER COATINGS (EPOXY)
INCINERATION
INTERNAL CATALYTIC
EXTERNAL CATALYTIC
INTERNAL THERMAL
EXTERNAL THERMAL

Notes:
(1) Has been used successfully in Europe.
(2) Available for specialized applications.
(3) Theoretically possible, but not commercially developed.

Source: Control of Volatile Organic Emissions from Existing Stationary Sources--Volume IV: Surface Coating for Insulation of Magnet Wire, EPA-450/2-77-033, December 1977.

EXHIBIT 9-12(1)
U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE SURFACE
COATING FOR INSULATION OF MAGNET WIRE

Affected Facility	Control Options	Typical Percent Reduction	Comparison of Control Options
Magnet wire coating ovens	Incineration		
	Catalytic, internal	75-95	All major wire oven designers now incorporate internal catalysts into their design. This design recirculates clean, heated air into the wire drying zone. However, this option will not be considered part of this study since it is not a retrofit option.
	Catalytic, external	75-95	An add-on option, this is energy intensive and is not easily adapted to primary heat recovery. Catalytic devices cannot be implemented where polyester amide-imide coatings are used, since they act as catalyst poison. Experimental catalysts are being developed to overcome this problem.
	Thermal, internal	98	Hot, clean gases can be recirculated back to the drying zone but this type of incinerator has not been popular with wire coaters because it is a high energy user.
	Thermal, external	98	This option is readily adaptable to both primary and secondary heat recovery.
	Low solvent coating	a	This option has not been developed with the properties that meet all wire coating needs
	Waterborne coating	80	Presently being used in small quantities, these are not available with properties suitable for all wire coating applications and don't have good high-temperature resistance.
	Powder coating	a	Applied to wire on an experimental basis. The upper temperature range of 130°C for epoxy powder coating is well below the 220°C operating temperature at which many types of electrical equipment must operate. Powder can be used only on large diameter wires. For finer wire, the powder particle approaches the wire diameter and will not adhere well to the wire.

EXHIBIT 9-12(2)
U.S. Environmental Protection Agency

Affected Facility	Control Options	Typical Percent Reduction	Comparison of Control Options
	Hot melt coating	a	This has been reported successful in Europe
	Ultraviolet cured coatings	a	This is available for specialized systems
	Electrodeposition coatings	a	This is theoretically possible; but once a layer of coating is applied by the wire, the surface is insulated against further electrodeposition.

---

a. Not available

Source: Control of Volatile Organic Emissions from Existing Stationary Sources--Volume IV: Surface Coating for Insulation of Magnet Wire EPA-450/2-77-003, December 1977

9.4.2 Selection of the Most Likely RACT Alternative

No substitute for solvent-based coating material, that can meet both the physical (high temperature) requirements of the magnet wire industry and the RACT guidelines for VOC emissions, has been developed. The industry has turned to incineration as the most likely means of meeting the RACT guidelines.

Because incineration is so energy intensive, the industry is seeking the most efficient and effective means of utilizing the scarce natural gas resource. Therefore, add-on incineration units will have to be equipped with both a catalyst and some form of heat recovery/recycle system.

One system presently being tested and successfully run under actual production conditions utilizes a combination catalyst, burner and "heat wheel" or rotary air-to-air exchange to recover heat from the oven. The auxiliary burner and catalyst serve to control the final exhaust temperature so that condensation and subsequent wheel plugging would be avoided.

This type of unit eliminates the need for natural gas as a source of heating the bottom zone (solvent evaporation zone) in the oven. Fresh air is preheated in the rotary exchanger and cycled to the bottom of the oven, while the exhaust gases are cleaned by the oven catalyst, cooled by the exchanger and discharged into the atmosphere. Even though this unit adds an auxiliary burner catalyst arrangement, there is an expected average 60 percent reduction in the oven's overall fuel requirement.

For those facilities which coat wire that does not have to meet high-temperature resistance requirements, waterborne coatings may be applicable but additional development work is required. One of the two facilities studied may be able to utilize waterborne coatings instead of add-on incineration, and has indicated its intention of pursuing that option, so that option is included in this report.

The alternatives are shown in Exhibit 9-13, on the following page.

EXHIBIT 9-13
U.S. Environmental Protection Agency
MOST LIKELY RACT CONTROL ALTERNATIVES
FOR SURFACE COATING FOR INSULATION
OF MAGNET WIRE IN THE STATE OF MICHIGAN

Affected Facility	Most Likely Alternative Control Techniques
Magnet wire needing high-temperature resistance properties	Catalytic incineration with heat recovery
Magnet wire coated at low-temperatures (150°F-300°F) and not needing high-temperature resistance properties	Catalytic incineration with heat recovery or waterborne coating (if available)

Source: Booz, Allen & Hamilton, Inc.

9.5 COST AND VOC REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Costs for the VOC emission control systems are presented in this section. The costs for add-on catalytic incineration with primary heat recovery are shown for one magnet wire coating facility. Waterborne coating is assumed applicable to the second facility. The final section presents an extrapolation of typical costs for surface coating of magnet wire to the statewide industry.

9.5.1 Costs for Alternative Control Systems

Estimates of capital and annualized costs are presented for controlling solvent emissions from oven areas in the coating of magnet wire for insulation.

The add-on modification to the magnet wire coating line consists of a catalytic incinerator with primary heat recovery. The waterborne coating option may require some temperature and humidity control changes, but at the present time information is not available on the specific changes or their costs. The modifications and their costs are shown in Exhibit 9-14, on the following page.

It is assumed that magnet wire products which require insulation coatings that have properties of high-temperature resistance are processed in high-temperature ovens which cannot now utilize waterborne or powder coating options to reduce VOC emissions and, therefore, require add-on incineration to meet RACT guidelines. Based on this assumption, the installed capital cost of add-on catalytic incineration with heat recovery is estimated at between $50,000 and $120,000 per unit. These equipment costs were developed from information supplied by manufacturers of control equipment. The total cost of incineration for the affected facilities assumes the need for nine large incinerators estimated at $100,000 each installed and four smaller incinerators estimated at $50,000 each installed. The basis for these assumptions is derived from industry interviews and data provided by the Illinois EPA on magnet wire emissions control.

The annual operating expenses for this option will be increased because of the need for additional manpower requirements (direct labor), amounting to one-half hour per shift per unit. For a 355-day-year and three shifts per day operation at $10 per man-hour, this amounts to an increase of $5,325 per unit per year in direct labor. Energy savings from primary heat recovery will be considerable, since all external heat requirements for the bottom zone will be eliminated. For the larger ovens that are part of this study, this means a possible savings of up to 5.5 billion BTU per year per oven or equivalent savings of 916 barrels of oil per year per oven.

EXHIBIT 9-14

U.S. Environmental Protection Agency

ESTIMATED COSTS FOR ADD-ON CATALYTIC INCINERATION MODIFICATION TO EXISTING MAGNET WIRE COATING LINES TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL

Existing System	Most Likely Control Alternative	Modification Description	Capital Cost
Magnet wire coating needing high-temperature resistance properties	Add-on incineration	Catalytic incineration with primary heat recovery (eliminates need for external heat sources for the bottom zone)	Installed capital: $50,000-$120,000 Annualized capital: $12,500-$30,000
Magnet wire coating not needing high-temperature resistance properties	Add-on incineration	Catalytic incineration (same as above)	Same as above
	Waterborne coating	Possible minor modifications to temperature and humidity controls in oven	a

---

a. Not available but assumed to be negligible based on industry interviews

Source: Booz, Allen & Hamilton, Inc.

Existing oven configurations can be used to accommodate waterborne coatings; however, information was not available on any other possible process modifications that might be required to utilize waterborne coatings.

9.5.2 Extrapolation to the Statewide Industry

Exhibit 9-15, on the following page, extrapolates the costs for meeting RACT guidelines for VOC emission control, for surface coating of magnet wire for insulation, to the statewide industry in Michigan. The estimates are based on the following assumptions:

- All coaters of magnet wire for insulation will implement the control alternatives stated in this report to comply with RACT.
- The four facilities identified by the Michigan EPA and from Booz, Allen interviews represent the majority of all the state production of coated magnet wire.
- Of the four plants identified as emitters, two companies have implemented after burners on all their lines and now meet the RACT guidelines.
- One of the two companies identified may have the option of implementing waterborne coatings instead of add-on incineration.
- There will be no change in costs, either capital or operating, for implementing waterborne coating.

Actual costs to magnet wire coaters may vary depending on the type of control alternatives, manufacturer's equipment and coating material selected by each coating facility.

Based on the above assumptions, the total capital cost to the industry in Michigan to meet RACT guidelines, with one of the facilities implementing add-on incineration and the other converting to waterborne coatings, is estimated at $1.0 million to $1.5 million. The annual cost is estimated at $739 to $1,256 per ton of emission controlled.

EXHIBIT 9-15
U.S. Environmental Protection Agency
STATEWIDE COSTS FOR ADD-ON INCINERATION OF EXISITING MAGNET WIRE COAT LINES TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL
MICHIGAN

Characteristic	
Uncontrolled emissions (ton/yr)	277
Potential emission reduction (ton/yr)	242
Installed capital cost ($ million)	1.0-1.5
Direct annual operating cost (credit) ($ thousand)	(71)
Annual capital charges ($ thousand)[a]	250-375
New annualized cost[b] ($ thousand)	179-304
Annual cost per ton of emission reduced ($)	739-1,256

---

a. Annual capital charges are assumed to be 25 percent of the installed capital charges and include depreciation, interest taxes, insurance, administrative charges and maintenance materials.

b. Net annualized cost is the summation of the direct annual operating cost and the annual capital charges.

Source: Booz, Allen & Hamilton, Inc.

9.6 DIRECT ECONOMIC IMPACTS

This section presents the direct economic impacts of implementing the RACT guidelines, for surface coating of magnet wire for insulation, on a statewide basis. The analysis includes the availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost passthrough), state economic variables and capital investment.

9.6.1 RACT Timing

RACT must be implemented statewide by January 1, 1982. This implies that surface coaters of magnet wire must have made their process modifications and be operating in compliance within the next four years. The timing requirements of RACT impose several requirements on magnet wire coaters:

- Determine the appropriate emission control system.
- Raise or allocate capital to purchase equipment.
- Acquire the necessary equipment for emission control.
- Install and test the emission control equipment to insure that the system complies with RACT.
- Generate sufficient income from current operations to pay the additional annual operating costs incurred with emission control.

The sections which follow discuss the feasibility and the economic implications of implementing RACT within the required timeframe.

9.6.2 Technical Feasibility Issues

Technical and economic feasibility issues of implementing the RACT guidelines are discussed in this section.

A manufacturer of an add-on catalytic incinerator unit with primary heat recovery reports that their unit has been successfully field-tested under actual production conditions. The manufacturer indicates that a 16-week to 20-week delivery schedule can be met, assuming a significant market demand based on industry response to RACT guidelines. In addition, industry representatives acknowledge this add-on catalytic incineration package as a viable alternative and are considering this option, as well as similar incineration packages available in the market. Research is continuing in the field of waterborne coatings, and it is expected that their commercial viability will be proven. However, the study team does not have enough data to make a judgment on whether development of viable waterborne coatings will coincide with the RACT guideline implementation schedule.

9.6.3 Comparison of Direct Cost with Selected Direct Economic Indicators

The net increase in the annualized cost to the coaters of magnet wire represents between 1 percent and 2 percent of the industry's 1977 value of shipments. This cost increase may translate to an increase of between $0.01 and $0.03 per pound of wire coated.

There is a significant increase in both capital costs and annualized costs. The estimated capital required for RACT compliance could represent a significant capital appropriation for the companies affected.

None of the companies interviewed wished to express an opinion on the possible direct economic effect to their operations, but they did express strong concern over the problem of capital drain and difficulty in passing costs along to the consumer.

9.6.4 Selected Secondary Economic Impacts

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

Employment is expected to remain unchanged. Market structure and productivity will also remain unchanged.

* * * *

Exhibit 9-16, on the following page, presents a summary of the current economic implications of implementing the RACT guidelines for surface coating for insulation of magnet wire in the state of Michigan.

EXHIBIT 9-16
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURFACE COATING FOR INSULATION OF MAGNET WIRE IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	There are four facilities that coat magnet wire, of which two do not meet the RACT emission limitations
Indication of relative importance of industrial section to state economy	1977 statewide value of shipments was estimated at $16 million and represents 2 percent of the estimated $830 million value of shipments of the magnet wire industry nationwide
1977 VOC emissions (actual)	465 tons per year, of which 277 are subject to control
Industry preferred method of VOC control to meet RACT guidelines	Waterborne coating or add-on catalytic incinerator with primary heat recovery
Assumed method of VOC control to meet RACT guidelines	Waterborne coatings (where applicable) or add on catalytic incinerator with primary heat recovery

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$1.5 million (estimated to be over 100 percent of current annual capital approximations of the affected facilities)
Annualized cost (statewide)	$240,000 which represents 1.5 percent of the industry's 1977 statewide value of shipments
Price	Increase of an average of $0.02 per pound of wire coated (based on a price of $1.20 per pound)
Energy	Reduced natural gas requirements due to primary heat recovery (equivalent to 10,000 barrels of oil per year)
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
RACT timing requirements (1982)	No problems meeting equipment deliveries and installation are anticipated
Problem area	Commercial application of waterborne coating has not been completely developed Large capital requirements will cause severe capital drain on the affected facilities
VOC emissions after RACT control	35 tons/year (13 percent of 1977 VOC emission level subject to control)
Cost effectiveness of RACT control	$1,000 annualized cost/ton VOC reduction

---

Note: Cost data are based on emission information supplied by the Michigan Department of Natural Resources

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

1972 Census of Manufactures, Nonferrous Metal Mills and Miscellaneous Primary Metal Products

Current Industrial Reports, Insulated Wire and Cable, 1976

Predicasts, No. 64 (July 27, 1976)

U.S. Industrial Outlook, 1977

Private conversations with the following:

Anaconda Wire and Cable, Muskegon, Michigan
Cass Wire Company, Cassopolis, Michigan
Essex International, Hillsdale, Michigan
General Electric, Fort Wayne, Indiana
Michigan Oven Corporation, Romulus, Michigan
Prestolite Wire Division, Eltra Corporation, Port Huron, Michigan

10.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF MICHIGAN

10.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF MICHIGAN

This chapter presents a detailed analysis of the impact of implementing RACT for surface coating of large appliances in the State of Michigan. The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Emissions and current controls
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of the application of surface coatings on large appliances, interviews and analysis.

10.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impacts

for the surface coating of large appliances in Michigan.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

10.1.1 Industry Statistics

The major appliance industry contains seven major industrial areas as defined by the Standard Industrial Code (SIC).

SIC Code	Description
3582	Commercial laundry
3585	Commercial refrigeration and air conditioning
3589	Commercial cooking and dishwashing
3631	Household cooking
3632	Household refrigerator and freezer
3633	Household laundry
3639	Household appliances, N.E.C. (includes water heaters, dishwashers, trash compactors)

Current Industrial Report provides detailed industry statistical data for the major appliance industry on a national basis. However, because of confidentiality and disclosure problems, there is no individual data source which provides a comprehensive analysis of the statistical data for each individual state. Therefore, our methodology to provide statewide major appliance statistical data was as follows:

- A list of potentially affected facilities was compiled from the state emission inventory, associations and trade journals.
- Interviews were performed with some of the manufacturers to validate the list of potentially affected facilities (this list was not 100 percent validated).
- Secondary source data were collected for each of the industry categories from sources such as:
  - Sales and Marketing Management (April 25, 1978)
  - 1972 Census of Manufactures
- The Booz, Allen study team, utilizing all available inputs, including interviews with selected manufacturers, determined an estimated percent of the total U.S. value of shipments applicable to the state in each SIC category.

For those categories which included products not included in this study, the value of shipments of these items were factored out of the totals.

Data on number of units shipped were not available for commercial appliances, so economic impact based on unit costs for the total large appliance industry could not be calculated.

10.1.2 VOC Emissions

Booz, Allen developed a listing of 12 facilities, identified as hydrocarbon emitters in the surface coating of large appliances, covered by RACT in the State of Michigan. This listing of industries subject to RACT guidelines for hydrocarbon emissions is based on information provided by the 1977 Michigan Air Pollution Reporting form instructions. The list, therefore, may not be all inclusive, or it may include some industries that may not be actually performing the coating operations indicated or identified by the RACT category. Sufficient data and resources were not available to verify each listing. The emissions for 1977 and only those facilities with greater than two tons per year total emission are included.

10.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions for the surface coating of large appliances are described in Control of Volatile Organic Emissions from Existing Stationary Sources -- Volume V: Surface Coating of Large Appliances, (EPA-450/2-77-034, December 1977). Several manufacturers of large appliances and coating application equipment were interviewed to ascertain the most feasible types of control for organic emissions in the coating of large appliances.

All manufacturers interviewed agreed that, currently, consideration was being given to meeting the present RACT deadlines through one modification to the existing topcoating equipment (i.e., high solids) and through two possible alternatives to primecoating operations (i.e., waterborne dip or flow coat or high solids), depending on the type of existing equipment. Therefore, the analysis for this report was based on these alternatives. The methodology for the cost analysis is described in the following paragraphs.

10.1.4 Cost of Control of VOC Emissions for Surface Coating of Large Appliances

The costs of control of volatile organic emissions for surface coating of large appliance were developed by:

- Determining the alternative types of control systems likely to be used
- Estimating the probable use of each type of control system
- Defining system components
- Developing installed capital costs for each alternative control system
- Defining a model plant
- Developing costs of a control system for the model plant:
    - Installed capital cost
    - Direct operating cost
    - Annual capital charges
    - Energy requirements
- Extrapolating model costs to individual industry sectors
- Aggregating costs to the total industry for the state.

The model plant that was used as a basis for establishing the cost of process modification to meet RACT was a solvent based dip (or flow coat) primecoat and a solvent based electrostatic bell or disc topcoat. The cost of modification to waterborne dip or flow coat primecoat and to high solids electrostatic disc or bell topcoat was not considered to be a function of the type of major appliance to be coated, since no modifications to the production lines are necessary. Modifications are required only to the coatings handling and pumping and spraying equipment, and these would be approximately the same whether washers, dryers or refrigerators were being coated.

Since industry interviewees indicated that about half the household appliance industry primecoats before topcoating and half does not, the costs of control for the industry will reflect the additional cost that half the industry must incur in having to convert both phases of its coating operation to meet RACT guidelines.

10.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements to implement RACT, assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Michigan.

10.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of large appliances in Michigan. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that are published for the base year), "B" indicates data that were extrapolated from hard data and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 10-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 10-1
U.S. Environmental Protection Agency
SURFACE COATING OF LARGE APPLIANCES
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		X	
Emissions	X		
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

10.2 INDUSTRY STATISTICS

Industry statistics and business trends for the manufacture and surface coating of large appliances in Michigan are presented in this section. The discussion includes a description of the number of facilities, a comparison of the size of the major appliance industry to the state economic indicators, a historical characterization of the industry and an assessment of future industry patterns. Data in this section form the basis for assessing the impact on this industry of implementing RACT to VOC emissions in Michigan.

10.2.1 Size of the Industry

Information from Michigan EPA Emission Reporting forms and Booz, Allen interviews identified 12 facilities participating in the manufacture and coating of large appliances, as shown in Exhibit 10-2, on the following page. These companies accounted for between $1.1 billion and $1.7 billion in shipments. The estimated number of employees in 1977 was between 7,000 and 9,000. The data and the sources of information are summarized in Exhibit 10-3, following Exhibit 10-2, and indicate that Michigan shipped an estimated 7 percent to 11 percent of the U.S. value of shipments.

10.2.2 Comparison of the Industry to the State Economy

A comparison of the value of shipments of large appliances (in the SIC categories stated previously) with the state economy indicates that the large appliance industry represents between 1.2 percent and 1.9 percent of the total Michigan value of shipments of all manufactured goods. The industry employs between 0.7 percent and 0.8 percent of all people employed in manufacturing in Michigan. These figures are shown in Exhibit 10-4 following Exhibit 10-3, along with the sources of the data.

10.2.3 Historical and Future Patterns of the Industry

The shipments of major appliances have generally followed the economic condition of the country. In the last ten years, sales have generally increased annually, except during the recession in 1974 and 1975. Shipments peaked in 1973 for all major appliances.

Shipments picked up in 1976 and continued to grow in 1977. The outlook through 1982 is a continued annual growth of about 3 percent to 5 percent.

EXHIBIT 10-2

U.S. Environmental Protection Agency
LIST OF MANUFACTURERS, POTENTIALLY AFFECTED BY RACT GUIDELINES, WHO SURFACE COAT LARGE APPLIANCES IN MICHIGAN

Facility Name	Location
Addison Products	Jonesville
Air Comfort Corp.	Albion
Bradford White Corp.	Middleville
David Products	Dowagiac
Fedders Refrigeration Co.	Greenville
Greenville Products Corp.	Greenville
Heat Controller Inc.	Jackson
Howell Industries	Lapeer
Kelvinator Inc.	Grand Rapids
Kysor Ind.	Marshall
Vernco Corp.	Menominee
Whirlpool Corp.	St. Joseph

Source: Michigan EPA Emission Reporting forms and Booz, Allen & Hamilton Inc. analysis

EXHIBIT 10-3

U.S. Environmental Protection Agency

INDUSTRY STATISTICS--SURFACE COATING OF LARGE APPLIANCES

MICHIGAN

SIC Code	RACT Category	U.S. Totals[a] 1977: Estimated No. of Units Shipped (thousand)	U.S. Totals[a] 1977: Estimated Value of Shipments ($ million)	Michigan Totals[a]: Estimated Percent of U.S. Shipments	Michigan Totals[a]: Estimated Value of Shipments ($ million)	Michigan Totals[a]: Estimated No. of Units Shipped (thousand)
3582	Commercial laundry	b	200	None	None	b
3585	Commercial refrigeration and air conditioning	b	9,500	8-12	750-1,200	b
3589	Commercial cooking and dishwashing	b	150	2-6	3-9	b
3631	Household cooking	5,000	1,500	2-4	30-60	100-200
3632	Household refrigerator and freezer	7,300	2,000	8-10	160-200	500-800
3633	Household laundry	8,500	1,500	8-12	120-180	600-1100
3639	Household appliances: Water heaters Dishwashers Trash compactors	9,300	800	5-7	40-60	400-700
	TOTAL		15,650	7-11	1,103-1,709	1,600-2,800

---

a. *Current Industrial Reports*, Major Household Appliances, 1977 (issued June 1978) for categories 3631, 3632, 3633 and 3639. *1972 Census of Manufactures* Service Industry Machine Shops (issued March 1975 and updated to 1977) for categories 3582, 3585 and 3589. *Sales and Marketing Management* (April 25, 1977) for categories 3631, 3632, 3633 and 3585.

b. Not available

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 10-4

U.S. Environmental Protection Agency

COMPARISON OF LARGE APPLIANCE STATISTICS WITH STATE OF MICHIGAN ECONOMIC DATA

	Estimated Michigan Economic Indicators	Estimated Percent of Michigan Manufacturing Economy Engaged in Large Appliance Manufacturing
Total 1977 value of shipments of all manufactured goods	$87-91 billion	1.2 to 1.9
Number of employees in manufacturing	1.0-1.2 million	0.7 to 0.8

Source: Current Industrial Reports, Major Household Appliances, 1977 (issued June 1978) for categories 3631, 3632, 3633 and 3639; 1972 Census of Manufactures Industry Machines and Machine Shops (issued March 1975 and updated to 1977) for categories 3582, 3585 and 3589; Sales and Marketing Management (April 25, 1977) for categories 3631, 3632, 3633 and 3585; Sales and Marketing Management, April 25, 1978; Annual Survey of Manufacturers, Statistics for States, Standard Metropolitan Statistical Areas, Large Industrial Counties and Selected Areas, 1976; Booz, Allen & Hamilton Inc.

The growth of the major appliance market will be reflected in the growth of the housing industry and the socio-economic effects of the trends toward smaller families, single-person households, higher energy costs and the like.

Historical and future growth patterns are shown in Exhibits 10-5 and 10-6, on the following pages.

EXHIBIT 10-5

U.S. Environmental Protection Agency

HISTORICAL U.S. SALES FIGURES--SELECTED MAJOR HOUSEHOLD APPLIANCES FOR 1968-1977

	Appliance Sales (Millions Of Units)									
Appliance	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Washer	2.9	4.4	4.1	4.6	5.1	5.5	4.9	4.2	4.5	4.9
Dryer	2.9	3.0	2.9	3.3	3.9	4.3	3.6	2.9	3.1	3.6
Range	4.4	4.5	4.5	4.3	4.8	5.0	4.1	3.6	4.2	4.7
Dishwasher	1.9	2.1	2.1	2.5	3.2	3.7	3.3	2.7	3.1	3.4
Refrigerator	5.2	5.3	5.3	5.7	6.3	6.8	5.9	4.6	4.8	5.7

Source: *Appliance*, April 1978, pp. 37-40.

EXHIBIT 10-6

U.S. Environmental Protection Agency

FIVE-YEAR U.S. SALES FORECAST FOR SELECTED MAJOR HOUSEHOLD APPLIANCES
(1978-1982)

Appliance	Appliance Estimates (Millions Of Units)				
	1978	1979	1980	1981	1982
Washer	5.4	5.6	5.7	5.8	5.8
Dryer	4.0	4.2	4.4	4.5	4.6
Range	5.2	5.4	5.6	5.7	5.8
Dishwasher	3.7	3.9	4.1	4.4	4.6
Refrigerator	6.0	6.2	6.4	6.5	6.6

Source: *Appliance*, January 1978, pp. 54-55.

10.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents the process description for the preparation, application and curing of surface coatings for large appliances.

10.3.1 Large Appliance Process Description

A large appliance plant typically manufactures one or two types of appliances and contains only one or two lines. The lines may range from 1,200 to 4,000 meters (3/4 mile to 2-1/2 miles) in length and operate at speeds of 3 to 15 meters (10 to 50 feet) per minute.

Cases, doors, lids, panels and interior parts for large appliances are stamped from sheet metal and hung on overhead conveyors. The parts are transported to the cleaning and pretreatment sections which are typically located on the ground floor of the plant.

Exhibit 10-7 and Exhibit 10-8, on the following pages, describe and illustrate the pretreatment, coating and curing processes for a typical large appliance facility.

EXHIBIT 10-7
U.S. Environmental Protection Agency
PRESENT MANUFACTURING TECHNOLOGY DESCRIPTION

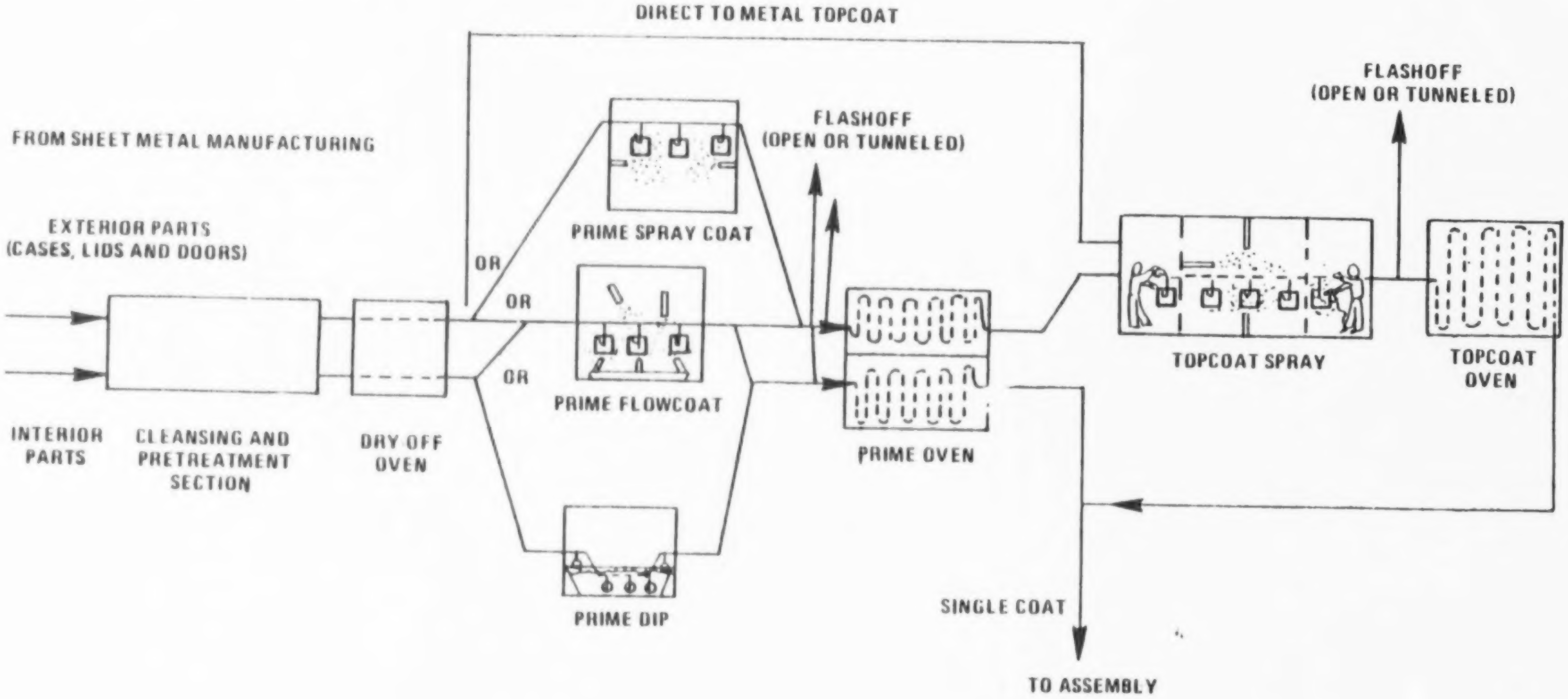
MANUFACTURING AND PRETREATMENT PROCESS DESCRIPTION	COATING PROCESS DESCRIPTION	CURING PROCESS DESCRIPTION	TYPICAL COATINGS AND SOLVENTS
Large appliance plant typically manufactures one or two different types of appliances and contains only one or two lines . Lines may range from 1,200 to 4,000 meters (3/4 to 2-1/2 miles) in length . Lines may operate at speeds of 3 to 15 meters (10 to 50 feet) per minute Parts are transported on overhead conveyors . Cleaned in an alkaline solution . Rinsed . Treated with zinc or iron phosphate . Rinsed again . Treated with chromate (if iron phosphate is used) · Dried at 300°F to 400°F in a gas fired oven and cooled before coating	Primecoat or interior single coat (0.5 to 1.0 mils) is applied . Dip coating occurs in a continuously agitated tank . Flow coating occurs in an enclosed booth as the parts move through on a conveyor and are sprayed by stationary or oscillating nozzles - Parts may enter a flash-off tunnel to allow coating to flow out properly . Spray coating occurs in booths either by automatic electrostatic spraying or manually - Flashoff of 7 minutes to allow solvents to rise slowly in the film to avoid popping in the oven Prior to topcoating, the parts are checked for smoothness and manually sanded, "tack-ragged" or retouched with a spray gun	Coated parts are baked for about 20 minutes at 180°C to 230°C (350°F to 450°F) in a multipass oven	Coatings include: . Epoxy . Epoxy-acrylic . Acrylic or polyester enamels . Alkyd resins Solvents include: . Esters . Ketones . Aliphatics . Alcohols . Aromatics . Ethers . Terpenes
Exterior parts may enter a prime preparation booth to check the pretreatment . Parts can be sanded and tack-ragged (wiped) to provide an even finish	Topcoat or exterior single coat (direct-to-metal topcoat (1.0 to 1.5 mils) is applied . Usually applied by automated electrostatic discs, bell or other type of spray equipment . Usually applied in many colors . Applied in side-draft or down-draft spray booths equipped with water wash and undergoes a 10-minute flashoff period Inside of many exterior large appliance parts are sprayed with gelsonite for additional moisture resistance and for sound deadening	Baked for 20 to 30 minutes at 140°C to 180°C (270°F to 350°F) in a multipass oven	

Source: Control of Volatile Organic Emissions from Existing Stationary Sources -- Volume V: Surface Coating of Large Appliances, EPA-450/2-77-034, December 1977.

EXHIBIT 10-8

U.S. Environmental Protection Agency

DIAGRAM OF A LARGE APPLIANCE COATING LINE


DIRECT TO METAL TOPCOAT
FROM SHEET METAL MANUFACTURING
EXTERIOR PARTS
(CASES, LIDS AND DOORS)
INTERIOR PARTS
CLEANSING AND PRETREATMENT SECTION
DRY OFF OVEN
OR
OR
OR
PRIME SPRAY COAT
PRIME FLOWCOAT
PRIME DIP
FLASHOFF
(OPEN OR TUNNELED)
PRIME OVEN
TOPCOAT SPRAY
FLASHOFF
(OPEN OR TUNNELED)
TOPCOAT OVEN
SINGLE COAT
TO ASSEMBLY

Source: Control Of Volatile Organic Emissions From Existing Stationary Sources--Volume V: Surface Coating Of Large Appliances, EPA-450/2-77-034, December 1977.

10.4 EMISSIONS AND CURRENT CONTROLS

This section presents information on the distribution of VOC emissions during the coating operation, the estimated VOC emissions in Michigan in 1977 and the current level of emission control implemented in the state.

VOC emissions occur in three areas during the process of coating large appliances. They are the application, flashoff and oven areas. The percent distribution of VOC emissions by area is as follows:

	Percent of VOC Emission	
Application Method	Application and Flashoff	Oven
Dip	50	50
Flow coat	60	40
Spray	80	20

The percent reduction of emissions for prime coating with waterborne dip of flow coat operations was assumed to be 80 percent and for high solids (62 percent volume) top coat 60 percent. An overall average of 70 percent reduction in VOC emissions is assumed in implementation of RACT guidelines for surface coating of large appliances.

Exhibit 10-9, on the following page, shows the total estimated emissions in tons per year from coaters of major appliances in Michigan. The estimated emissions in Michigan from 12 appliance coating facilities are 1,012 tons per year.

10.4.1 RACT Guidelines

The RACT guidelines for control of VOC emissions from the surface coating of major appliances require the following:

- Use of waterborne, high solids (at least 62 percent by volume) or powder coating to reduce VOC emissions
- Use of add-on control devices, such as incinerators or carbon adsorbers.

Exhibits 10-10, 10-11 and 10-12, following Exhibit 10-9, summarize the RACT emission limitations and control options for VOC emissions control for surface coating of large appliances.

EXHIBIT 10-9

U.S. Environmental Protection Agency

RACT DATA SUMMARY OF ESTIMATED VOC EMISSIONS FOR SURFACE COATERS OF LARGE APPLIANCES IN STATE OF MICHIGAN

Facility Name	Current Average Hydrocarbon Emissions (Ton/Year)	Potential Control Efficiency with RACT (Percent)	Potential Emission Reduction with RACT (Ton/Year)
Addison Products	68	70	48
Air Comfort Corp.	24	70	17
Bradford White Corp.	78	70	55
Davis Products	4	70	3
Fedders Refrigeration Co.	30	70	21
Greenville Products Corp.	230	70	161
Heat Controller Inc.	3	70	2
Howell Industries	60	70	42
Kelvinator Corp.	270	70	189
Kysor Ind.	15	70	11
Vernco Corp.	10	70	7
Whirlpool Corp.	220	70	154
Total	1,012		710

Source: Booz, Allen and Hamilton Inc. analysis of Michigan State Emission Inventory

EXHIBIT 10-10

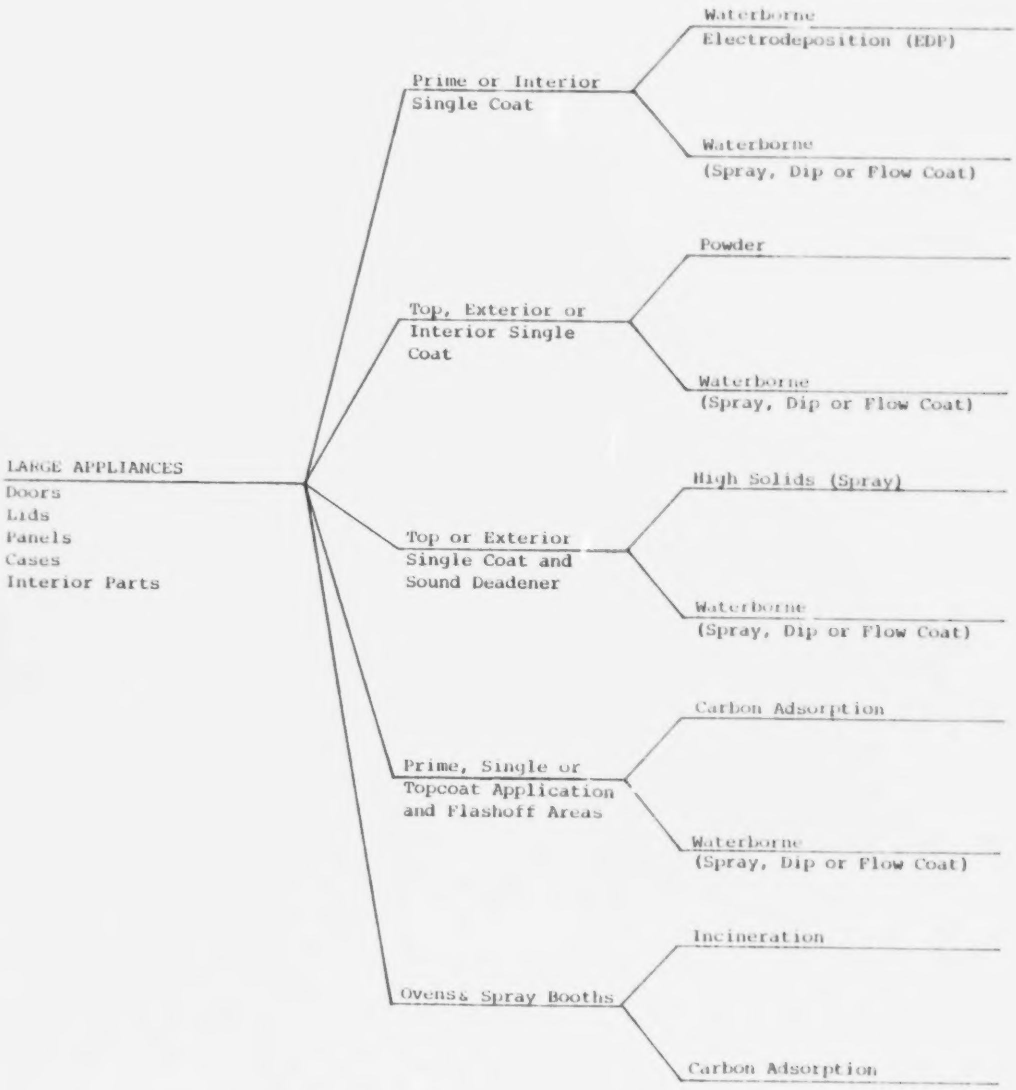
U.S. Environmental Protection Agency EMISSION LIMITATIONS FOR RACT IN THE SURFACE COATING OF LARGE APPLIANCES

	Recommended Limitations For Low Solvent Coatings	
Affected Facility	kg solvent per liter of coating (minus water)	lbs. solvent per gallon of coating (minus water)
Prime, single or topcoat application area, flash-off area and oven	0.34	2.8

Source: Control of Volatile Organic Emissions from Existing Stationary Sources--Volume V: Surface Coating of Large Applications, EPA-450/2-77-033, December 1977.

EXHIBIT 10-11

U.S. Environmental Protection Agency
SUMMARY OF APPLICABLE CONTROL TECHNOLOGY FOR COATING OF LARGE APPLIANCE DOORS, LIDS, PANELS, CASES AND INTERIOR PARTS


LARGE APPLIANCES
Doors
Lids
Panels
Cases
Interior Parts
Prime or Interior Single Coat
Waterborne Electrodeposition (EDP)
Waterborne (Spray, Dip or Flow Coat)
Top, Exterior or Interior Single Coat
Powder
Waterborne (Spray, Dip or Flow Coat)
Top or Exterior Single Coat and Sound Deadener
High Solids (Spray)
Waterborne (Spray, Dip or Flow Coat)
Prime, Single or Topcoat Application and Flashoff Areas
Carbon Adsorption
Waterborne (Spray, Dip or Flow Coat)
Ovens& Spray Booths
Incineration
Carbon Adsorption

Source: Control Of Volatile Organic Emissions From Existing Stationary Sources--Volume V: Surface Coating of Large Appliances, EPA-450/2-77-034, December 1977.

EXHIBIT 10-12(1)

U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE
LARGE APPLIANCE INDUSTRY

Affected Facility and Application	Control Options	Typical Percent Reduction	Comparison of Control Options
Prime or interior single coat	Waterborne (electrodeposition, EDP)	90-95[a]	Provides excellent coverage corrosion protection and detergent resistance Fire hazards and potential toxicity are reduced Dry off oven may be omitted after cleansing if an iron-phosphate pretreatment is used Lower energy consumption via lower ventilation requirements Good quality control due to fully automated process may be offset by increased electrical requirements for the coating, refrigeration and circulation systems if EDP replaces waterborne flow or dip coating operations This would not be true if EDP replaces a spraying operation EDP can be expensive on small-scale production lines
All applications	Waterborne (spray dip or flow coat)	70-90[a]	This will likely be the first option considered because of the possibility that these coatings can be applied essentially with existing equipment Requires a longer flash-off area than organic solvent-borne coatings Curing waterborne coatings may allow a decrease in oven temperature and some reduction in airflow but limited reduction if high humidity conditions occur

EXHIBIT 10-12(2)
U.S. Environmental Protection Agency

Affected Facility and Application	Control Options	Typical Percent Reduction	Comparison of Control Options
			Spraying electrostatically requires electrical isolation of the entire system. Large lines may be difficult to convert because coating storage areas may be hundreds or thousands of feet away from the application area Dip or flow coating application requires closer monitoring due to their sensitive chemistry Weather conditions affect the application, so both flash-off time, temperature, air circulation and humidity must be frequently monitored Changes in the number of nozzles may be required Sludge handling may be more difficult
Top, exterior or interior single coat	Powder	95-99^a	No solid or liquid wastes to dispose of Powder may reduce energy requirements in a spray booth and the ovens because less air is required than for solvent-borne coatings and flash-off tunnel is eliminated Powder can be reclaimed resulting in up to 98% coating efficiency All equipment (spray booths, associated equipment and often ovens) used for liquid systems must be replaced Powder films cannot be applied in thicknesses in less than 2 mils and have appearance limitations Powder coatings may be subject to explosions Excessive downtime (half-hour) is required during color changes. If powders are not reclaimed in their respective colors, coating usage efficiency drops to 50% to 60%

EXHIBIT 10-12(3)
U.S. Environmental Protection Agency

Affected Facility and Application	Control Options	Typical Percent Reduction	Comparison of Control Options
Top or exterior single coat and sound deadener	High solids (spray)	60-80[a]	May be applied with existing equipment
			Reduces energy consumption because it requires less airflow in the spray booth, oven and flash-off tunnel
			Potential health hazard associated with isocyanates used in some high-solid two-component systems
Prime, single of top coat application and flash-off and spray booths	Carbon adsorption	90[b]	Although it is technically feasible, no larger appliance facilities are known to use carbon adsorption
			Additional energy requirements is a possible disadvantage
			Additional filtration and scrubbing of emissions from spray booths may be required
			There is little possibility of reusing recovered solvents because of the variety of solvent mixtures
			Many facilities may require dual-bed units which will require valuable plant space
			Particulate and condensible matter from volatilization and/or degradation of resin occuring in baking ovens with high temperature could coat a carbon bed
Ovens	Incineration	90[b]	These are less costly and more efficient than carbon adsorbers for the baking ovens because the oven exhaust temperatures are too high for adsorption and the high concentration of organics in the vapor could provide additional fuel for the incinerator
			Heat recovery system to reduce fuel consumption would be desirable and would make application and flash-off area usage a viable option

---

[a] The base case against which these percent reductions were calculated is a high organic solvent coating which contains 25 volume percent solids and 75 percent organic solvent. The transfer efficiencies for liquid coatings were calculated to be 80 percent, for powders about 93 percent and for electrodeposition about 99 percent.

[b] This percent reduction in VOC emissions is only across the control device and does not take into account the capture efficiency.

Source: Control of Volatile Organic Emissions from Existing Stationary Sources--Volume V: Surface Coatings of Large Appliances EPA-450/2-77-034 December 1977

10.4.2 Selection of the Most Likely RACT Alternatives

The choice of application of control alternatives, for the reduction of hydrocarbon emissions in existing facilities for the surface coating of large appliances, requires a line-by-line evaluation. A number of factors must be considered, based on the individual characteristics of the coating line to be controlled. The degree of economic dislocation is a function of these factors.

The first factor to be considered is whether the existing equipment can be used by the substitution of a coating material which will meet the RACT guidelines. This alternative would require the least capital expenditure and minimize production downtime.

If the existing equipment has to be modified, replaced or added to, factors to consider are the kind of changes that have to be made, the capital costs, the change in operating costs, the length of time needed to make the changes, the effect on the production rate, the operational problems that will have to be handled and the effect on the quality of the product.

Interviews with industry representatives indicate a unanimous opinion in the area of choosing the alternative(s) for VOC emission control in coating large appliances. The industry intends to use their existing topcoat application equipment and modify it to handle high solids. Those companies that use a primecoat will convert their conventional solvent systems to either waterborne dip or flow coat or high solids discs or bells. The alternatives are shown in Exhibit 10-13, on the following page.

EXHIBIT 10-13

U.S. Environmental Protection Agency
MOST LIKELY RACT CONTROL ALTERNATIVES FOR SURFACE COATING OF LARGE APPLIANCES IN STATE OF MICHIGAN

Coat	Existing System	Most Likely Alternative Control Techniques
Prime	Dip or flow coating with conventional solvent	Dip or flow coating with waterborne solvent Electrostatic application with discs or bells of high solids coatings . Preheat paint, or . Use high speed discs or bells
Top	Electrostatic application with discs or bells of conventional solvents	Electrostatic application with discs or bells of high solids coating . Preheat paint, or . Use high speed discs or bells

Source: Booz, Allen & Hamilton, Inc.

10.5 COST AND VOC REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Cost for the VOC emission control systems are presented in this section. The costs for the alternative primecoat and topcoat applications are described individually. The final section presents an extrapolation of typical costs for surface coating of large appliances to the statewide industry.

10.5.1 Costs for Alternative Control Systems

Estimates of capital and annualized costs are presented for controlling solvent emissions from application areas and curing ovens in primecoats and topcoats of large appliances.

The process modifications involve the converting of a solvent-borne primecoat or topcoat line to a coating system which emits lesser amounts of VOC. The coating lines and the costs for their modification are shown in Exhibit 10-14, shown on the following page.

If an existing primecoat conventional-solvent-based dip operation is converted to waterborne dip, the capital costs cover the requirements for additional equipment for close humidity and temperature control during flashoffs and for changeover to materials handling system (pumps and piping) that can handle waterborne coatings without corrosion related problems. Based on these assumptions, the capital installed cost of these modifications is estimated at between $50,000 and $75,000. No additional floor space is required so the capital allocated building costs remain unchanged. The fixed costs associated with the increased capital requirements are estimated at between $15,000 and $20,000. This includes depreciation, interest, taxes, insurance, administration expenses and maintenance materials.

For the conversion of primecoat or topcoat solvent-based electrostatic disc or bell spray to high solids, the cost of such conversion is based on a number of assumptions: that the paint will have to be preheated to reduce the viscosity prior to application, that the existing pumping system will have to be replaced (including the installation of larger capacity/head pumps and large diameter piping) and that high speed (25,000 to 50,000 RPM) turbine or air drive discs or bells will be required. Also, it is assumed that the type of booth remains unchanged and that the existing painting configuration (including the proper indexing layout requires no change.

EXHIBIT 10-14

U.S. Environmental Protection Agency

ESTIMATED COST FOR PROCESS MODIFICATION
OF EXISTING LARGE APPLIANCE COATING LINES
TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL

Existing System	Most Likely Control Alternative	Major Process Modification	Capital Cost
Primecoat			
Conventional solvent-based dip or flow	Waterborne dip of flow coat	Instrumentation for close control of temperature and humidity Total repiping and replacement of pumps	Installed capital $50,000 - $75,000 Annualized cost $13,000 - $19,000
Conventional solvent-based electrostatic spray, disc or bell	High solids electrostatic	Pre-heating system Installation of high disc or bells Repiping for larger line sizes and possible coatings pump replacements	Installed capital $50,000 - $75,000 Annualized cost $13,000 - $19,000
		Major revamp of booth line configuration and air handling system in addition to changes stated above	Installed capital $150,000 - $250,000 Annualized cost $37,000 - $63,000
Topcoat			
Conventional solvent-based electrostatic spray, disc or bell	High solids electrostatic	Preheating system Installation of high speed disc or bells Repiping for larger line sizes and possible coatings pump replacement	Installed capital $50,000 - $75,000 Annualized cost $13,000 - $19,000
		Major revamp of booth configuration and air handling system in addition to changes stated above	Installed capital $150,000 - $250,000 Annualized cost $37,000 - $63,000

Source: Booz, Allen & Hamilton Inc.

Based on these assumptions, the capital installed cost of these modifications is estimated at between $50,000 and $75,000. No additional floor space is required so the capital allocated building costs remain unchanged. The fixed costs associated with the increased capital requirements are estimated at between $13,000 and $19,000. This includes depreciation, interest, taxes, insurance, administration expenses and maintenance materials.

Each paint application conversion to meet RACT has its own unique characteristics. Where such conversions require major changes in booth structure, paint application techniques and air handling system, the costs will be considerably higher than the figures stated above. A first pass estimate, provided from industry interviews with appliance coaters, at these major changes indicates a capital requirement of $150,000 to $250,000 per booth. The annualized costs would be $37,000 to $63,000. Based on industry interviews and Booz, Allen judgment, it is assumed that 50 percent of the topcoating application units will require major modifications.

The annual operating expenses will not change appreciably because the manpower requirements remain the same for the two systems. There will be a minor savings in the utilities, associated with the oven curing of the high solids coating. This could amount to about $1 per hour of operation time ($2,000 to $6,000 per year per line (equivalent to 700 cubic feet of natural gas/hour/line).

The overall cost of coating materials may increase slightly even though conversion to water-based or high solids coating will eliminate the need for solvent thinning. This overall increase is expected because of the anticipated price increases in the coatings that will be required to meet the RACT guidelines. At this time, definitive numbers in change of paint prices cannot be developed but an overall paint cost increase of between 10 percent and 20 percent may be anticipated.

10.5.2 Extrapolation to the Statewide Industry

Exhibit 10-15, on the following page, extrapolates the costs for meeting RACT guidelines for VOC emission control for surface coating of large appliances to the statewide industry in Michigan. The estimates are based on the following assumptions:

- All large appliance coaters will implement the control alternatives stated in this report to comply with RACT.

EXHIBIT 10-15

U.S. Environmental Protection Agency

STATEWIDE COSTS FOR PROCESS MODIFICATIONS OF EXISTING LARGE APPLIANCE COATING LINES TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL

MICHIGAN

Characteristic	Plants with Topcoat Process Only	Plants with Primecoat and Topcoat Process	Total
Number of plants	6	6	12
Number of process lines	12	12	24
Estimated value of shipments ($ billion)	a	a	1.1-1.7
Uncontrolled emissions (Ton/yr)	a	a	1,000
Potential emission reduction (Ton/yr)	a	a	700
Installed Capital Cost[b] ($ Thousand)	1,950	2,850	4,800
Direct annual operating cost (credit) ($ Thousand) (1-3 shifts/day)	(24-72)	(24-72)	(48-144)
Annual capital charges[b] ($ Thousand)	488	712	1,200
Net annualized cost[c] ($ Thousand)	416[d]-464[e]	640[d]-688[e]	1,056[d]-1,152[e]
Annual cost per ton or emission reduced ($)	a	a	1,508[d]-1,645[e]

---

a. Not available

b. Figures represent the upper limit of the installed capital cost, and annual capital charges.

c. Net annualized operating cost is the summation of the direct annual operating cost and the annual capital charges

d. Represents a three shift/day operation

e. Represents a one shift/day operation

Source: Booz, Allen & Hamilton Inc.

- The distribution of primecoat or topcoat or both as applications, as per industry interview, is: 50 percent of the coaters topcoat only; the other half both primecoat and topcoat the appliances, unless specific information was available for individual facilities.
- Each plant is assumed to have two process lines.
- Also 50 percent of the topcoat applications require major modifications to meet RACT.
- The 12 plants identified by the Michigan EPA and from Booz, Allen interviews represent the majority of all the state industry production of large appliances.
- For the specific alternatives listed in Exhibit 10-14, the cost of process modifications for the prime or top coat operations are the same.

Actual costs to large appliance coaters may vary depending on the type of control alternative, manufacturer's equipment and coating material selected by each manufacturing facility.

Based on the above assumptions, the total capital cost to the industry in Michigan for process modifications to meet RACT guidelines is estimated at approximately $4.8 million. The annual cost is estimated at $1,508-$1,645 per ton of emission controlled.

10.6 DIRECT ECONOMIC IMPACTS

This section presents the direct economic impacts of implementing the RACT guidelines for surface coating of large appliances on a statewide basis. The analysis includes the availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost passthrough), state economic variables and capital investment.

10.6.1 RACT Timing

RACT must be implemented statewide by January 1, 1982. This implies that surface coaters of large appliances must have made their process modifications and be operating within the next four years. The timing requirements of RACT impose several requirements on major appliance coaters:

- Determine the appropriate emission control system.
- Raise or allocate capital to purchase equipment.
- Acquire the necessary equipment for emission control.
- Install and test the emission control equipment to insure that the system complies with RACT.
- Generate sufficient income from current operations to pay the additional annual operating costs incurred with emission control.

The sections which follow discuss the feasibility and the economic implications of implementing RACT within the required timeframe.

10.6.2 Technical Feasibility Issues

Technical and economic feasibility issues of implementing the RACT guidelines are discussed in this section.

Only one major appliance manufacturer interviewed has attempted to implement the control alternatives discussed in this report. The company has converted its conventional solvent flow primecoat to water reducible flow coat.

Although a longer flash-off period for water reducible coatings is usually required, there was not enough floor space available to add the process line. However, additional heating was added and the flash-off area temperature was elevated to 130°F-180°F. Also, extensive humidity controls had to be added because of the sensitivity of water reducible finish to moisture in the flash-off area.

The facility also has attempted the application of medium solids polyester (55 percent to 60 percent by volume) as a top-coat, using the existing electrostatic discs. There has been no attempts at pre-heating the paint, and the discs have been run at 2,400 RPM to 3,300 RPM. The unit, as it is presently constituted, will not apply 62 percent volume solids or higher. Pre-heat and/or higher speed disc modifications will have to be made to handle the more viscous coatings. Under the present operating conditions, the facility is not meeting the RACT guidelines for solvent emission control.

The equipment manufacturers interviewed have indicated that present technology is available to handle and apply high solids (greater than 62 volume percent solids) using electrostatic discs or bells. This requires the use of pre-heaters and high speed application. In addition, high solids coating material suppliers indicated that sufficient quantities of paint would be available to meet the expected market demand. Application equipment manufacturers have indicated that, even with the projected demand for their equipment they can maintain a 10-week to 12-week delivery schedule.

10.6.3 Comparison of Direct Cost With Selected Direct Economic Indicators

The net increase in the annual operating cost to the coaters of large appliances represents approximately 0.08 percent of the industry's 1977 value of shipments manufactured in the state. This may translate to an approximate cost increase of $0.20 per unit of household appliances coated; the average cost of a unit is $193.

The major economic impact in terms of cost to individual companies will be capital related rather than from increased annual operating costs. The capital required for RACT compliance may represent a significant amount of capital appropriations for the companies affected.

Any marginally profitable companies may be severely affected, although none of the companies interviewed had considered going out of business because of the projected increased capital requirements and inability to pass on these costs through higher prices.

10.6.4 Selected Secondary Economic Impacts

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

Employment is expected to remain unchanged. Employment would be reduced if marginally profitable facilities closed, but the present indication from the industry is that no such closures are anticipated.

It appears that implementation of the RACT guidelines will have no significant impact on the present market structure. The major appliance industry can be characterized as being highly competitive and manufacturers interviewed state that the regulation may present some cost inequities to smaller and/or less profitable production lines, i.e., if certain manufacturers incur disproportionate compliance costs they probably will not be passed along in the marketplace in the form of a price increase and could further deteriorate the profit position of marginally profitable operations.

Productivity for those coaters who are topcoating only with high solids may be increased if they are able to get more paint on per unit volume and reduce paint application time.

* * * *

Exhibit 10-16, on the following page, presents a summary of the current economic implications of implementing RACT for surface coating of large appliances in the State of Michigan.

EXHIBIT 10-16

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	There are twelve major large appliance manufacturers and coaters
Indication of relative importance of industrial section to state economy	1977 statewide value of shipments was estimated at $1.4 billion and represents 9 percent of the estimated $15 billion U.S. value of shipments of the major appliance industry
1977 VOC emissions (actual)	1,000 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Waterborne primecoat and high solids topcoat
Estimated method of VOC control to meet RACT guidelines	Waterborne primecoat and high solids topcoat

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$4.8 million
Annualized cost (statewide)	$1.1 million which represents 0.08 percent of the industry's 1977 statewide value of shipments.
Price	Assuming a "direct cost pass-through"--increase of $0.20/unit for household appliances (based on a price of $193 per unit appliance)
Energy	Reduced natural gas requirements in the curing operation (equivalent to 2,400 barrels of oil per year)
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
RACT timing requirements (1982)	Possible problem meeting equipment deliveries and installation are anticipated if majority of firms require deliveries in the same time frame
Problem area	Commercial application of high solids (greater than 62% by volume) has not been proven
VOC emission after RACT control	300 tons/year (30 percent of 1977 emission level)
Cost effectiveness of RACT control	$1,576 annualized cost/ton VOC reduction

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Appliance, April 1978

Annual Survey of Manufactures, 1976

Census of Manufactures, Industry Machines and Machine Shops, 1972

Current Industrial Reports, Major Household Appliances, 1977

Sales and Marketing Management, April 24, 1978

U.S. Environmental Protection Agency, *Control of Volatile Organic Emissions from Existing Stationary Sources--Volume V: Surface Coating of Large Appliances*. EPA-450/2-77-034, December 1977.

Private conversations with the following:

Addison Products, Jonesville, Michigan
Air Comfort Corp., Albion, Michigan
Association of Home Appliances Manufacturers, Chicago, Illinois
Bradford White Corp., Middleville, Michigan
Davis Products, Dowagiac, Michigan
Fedders Refrigeration Co., Greenville, Michigan
Ferro Corporation, Cleveland,Ohio
Greenville Products Corp., Greenvile, Michigan
Heat Controller Inc., Jackson, Michigan
Interrad, Stamford, Connecticut
Kelvinator Inc., Grand Rapids, Michigan
Nordsen Corporation, Amherst, Ohio
Ransburg Corporation, Indianapolis, Indiana
Whirlpool Corp., St. Joseph, Michigan

11.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SOLVENT METAL CLEANING (DEGREASING) IN THE STATE OF MICHIGAN

11.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SOLVENT METAL CLEANING (DEGREASING) IN THE STATE OF MICHIGAN

This chapter summarizes the estimated economic impact of the implementation of reasonably available control technology for volatile organic compound emissions from solvent metal degreasers. Solvent metal degreasing is the process of cleaning the surfaces of articles to remove oil, dirt, grease and other foreign material by immersing the article in a vaporized or liquid organic solvent. The chapter is divided into six sections:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Estimated costs of RACT implementation
- Direct economic impacts
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines; previous studies of solvent metal cleaning; interviews with degreaser users and with equipment and materials suppliers; and a review of pertinent published literature.

11.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATE

11.1.1 Background

Solvent metal cleaning is normally done in one of three devices:

- A cold cleaner, in which the article is immersed, sprayed or otherwise washed in a solvent at or about room temperature
- An open top vapor degreaser, in which the article is suspended in a solvent vapor over a pool of boiling solvent. The solvent vapors condense on the article and dissolve or wash soils and greases from it
- A conveyorized degreaser, in which articles are conveyed on a chain, belt or other conveying system either through a spray or pool of cold solvent or through a vapor of a boiling solvent.

The cold cleaner and open top vapor degreaser are designed for batch cleaning and are used in both manufacturing operations and maintenance operations. The conveyorized cleaners are designed for continuous use and are normally found only in manufacturing operations. A more detailed discussion of these cleaners is presented in a later section of this chapter.

The EPA has estimated[1] that about 1.3 million cold cleaners operate in the U.S.; about 70 percent are used in maintenance or service cleaning and 30 percent in manufacturing. There are also an estimated 22,200 open top vapor degreasers and 4,000 vapor conveyorized degreasers. In 1975, estimated emissions in the United States from these cleaners exceeded 700,000 metric tons, making solvent cleaning the fifth largest stationary source of organic emissions.

---

[1] Control of Volatile Organic Emissions from Solvent Metal Cleaning, EPA-450/2-77-022, November 1977.

As recently as 1974, degreasing operations were exempt from regulation in sixteen states, since they rarely emitted more than the 3,000 pounds per day of volatile organic compounds (VOC) which was the regulatory level then in effect in these states. They could also qualify for exemption by the substitution of a solvent not considered to be photochemically active. However, the EPA's current direction is toward positive reduction of all VOC emissions, and the EPA has proposed control technology for solvent metal cleaning operations which can achieve sizeable total VOC emission reduction. This technology involves the use of proper operating practices and the use of retrofit control equipment.

Proper operating practices are those which minimize solvent loss to the atmosphere. These include covering degreasing equipment whenever possible, properly using solvent sprays, employing various means to reduce the amount of solvent carried out of the degreaser on cleaned work, promptly repairing leaking equipment and most important, properly disposing of wastes containing volatile organic solvents. In addition to proper operating practices, many control devices can be retrofitted to existing degreasers; however, because of the diversity in their designs, not all degreasers require the same type of control devices. Small degreasers using a room temperature solvent may require only a cover, whereas large degreasers using boiling solvent may require a refrigerated freeboard chiller or a carbon adsorption system. Two types of control equipment which will be applicable to many degreaser designs are drainage facilities for cleaned parts and safety switches and thermostats, which prevent large emissions from equipment malfunction. These controls, the types of degreasers to which they can be applied and the expected emission reductions are described later in this chapter.

11.1.2 Method of Estimation of the Number of Degreasers

Subsequent estimation of the economic impact of implementing the proposed RACT for solvent metal cleaning is based upon a determination of the number of solvent metal cleaners in the state. This determination was made on the basis of a detailed industrywide study of metal degreasing in the U.S., conducted by the Dow Chemical Company under contract to the EPA. The results of the study are reported in: Study to Support New Source Performance Standards for Solvent Metal Cleaning Operations, Contract No. 68-02-1329, June 30, 1976.

The report was based on a telephone survey of more than 2,500 plants in the metal working industry (SIC groups 25, 33, 34, 35, 36, 37, 38 and 39) with more than 19 employees. The report presents estimates of the:

- Percentage of U.S. plants using solvent degreasing
- Percentage of plants using cold cleaners, open topvapor degreasers or conveyorized cleaners
- Average number and type of vapor degreasers used in these plants
- Distribution of these quantities by region.

All of these quantities are further identified by the eight metal working industries. In the report (based on the 1972 Census of Manufactures) 15,294 open top and 2,796 conveyorized vapor degreasers were estimated to be in use in the eight SIC groups; an additional 5,000 to 7,000 open top degreasers were estimated[1] to be in use in 1972 in manufacturing or service firms not included in one of the eight SIC groups or in firms with less than 20 employees.

To determine the number of open top and conveyorized vapor metal degreasers in the state, first the number of plants with more than 19 employees in each of the eight SIC groups was determined for the state. The average number of plants using solvent metal degreasing and the average number and type of cleaners used per plant were then obtained by using the factors presented in the Dow report. The results of these calculations and the factors used are tabulated in Exhibit 11-1, in section 11.2. The total number of open top degreasers in the state was then estimated by multiplying the number expected to be used in the eight metal working SIC groups by the ratio of 22,200/15,200 (the ratio of total open top units in the U.S. to that used in the eight SIC groups in the U.S.).

Because of their expense and function, conveyorized vapor degreasing units are most likely to be used in manufacturing only. Therefore, the total number of these units in the state was assumed to be same as that calculated for the eight SIC metal working industries. The total number of conveyorized cleaners, vapor and cold, was then determined by multiplying the number of vapor conveyorized cleaners by 100/85, the EPA[1] estimated ratio of total conveyorized cleaners to vapor conveyorized cleaners in the U.S.

---

[1] Interviews with Parker Johnson, Vice President, Sales, Baron Blakeslee Corp., Cicero, Illinois and with Richard Clement, Sales Manager, Detrex Chemical, Detroit, Michigan, July 1978.

The number of cold cleaners in the state was based on the Dow estimates of cold cleaning done in plants in the eight SIC metal working industries and the EPA[1] estimate of 1,300,000 cold metal cleaners in the U.S., which include 390,000 in manufacturing use and 910,000 in maintenance or service use.[2] Then:

- The EPA estimates of all cold cleaners in manufacturing use in the U.S. were multiplied by the ratio of the number of plants in the metal working industries (SICs 25 and 33-39) in the state to the number in the U.S.

- The EPA estimates of all cold cleaners in maintenance and service use in the U.S. were multiplied by the ratio of the number of plants in the metal working industries plus selected service industries (SIC codes 551, 554, 557, 7538, 7539, 7964) for the state to the number in the U.S. These service industries are expected to have at least one or more cold cleaners.

    - SIC 551 applies to industries categorized as new or used car dealers.

    - SIC 554 applies to industries categorized as gasoline service stations.

    - SIC 557 applies to industries categorized as motorcycle dealers.

    - SIC 7538 applies to industries categorized as general automotive repair shops.

    - SIC 7539 applies to industries categorized as automotive repair shops, n.e.c.

    - SIC 7964 applies to industries categorized as armature rewinding shops.

The estimates of the total number of cold cleaners in the state obtained by these calculations are tabulated in Exhibit 11-2.

---

[1] Control of Volatile Organic Emissions from Solvent Metal Cleaning EPA-450/2-77-002, November 1977.

[2] Cold cleaners in manufacturing use are meant to include only those cleaners employed in the manufacturing process; cold cleaners in maintenance and service use are those employed for this purpose by either manufacturing or service establishments.

11.1.3 Method of Estimation of Affected Degreasers

The RACT guidelines propose several exemptions for degreasers based primarily on size, type of solvent used or emission rate.

- Cleaners used exclusively for chemical or physical analysis or determination of product quality and acceptance are to be exempt. Since few such cleaners exist, no correction was made to the estimated number of cleaners used in determining the estimated compliance costs.
- Those cleaners using 1,1,1-trichloroethane and trichlorotrifluoroethane are to be exempt. Estimates of the number of open top degreasers which use either of these solvents range from 35 percent to 60 percent.[2] For the purpose of calculating cost impacts in this study, 35 percent was used. About 10 percent of conveyorized cleaners are expected to be exempt[2] and about 20 percent of cold cleaners.[1]
- Open top vapor degreasers with less than one square meter (10.8 square feet) air/vapor interface and conveyorized degreasers with less than two square meters (21.6 square feet) are to be exempt. This exemption applies to about 30 percent of open top cleaners and 5 percent of conveyorized degreasers.[2]

The guidelines leave open to the degreaser user the option of changing from a nonexempt solvent to an exempt one. In most cases, this will require some modification of the degreaser and an additional expense for the modification. In this study it was assumed that no substitution is made. In most cases 1,1,1 trichloroethane would be used as a substitute for existing solvents; this would require equipment conversions because of potential corrosiveness and other properties of this compound. Estimation of costs of conversion were not made since data are unavailable on the number of systems which could be converted. If Freon 113 were used as a substitute, new cleaners would probably have to be purchased.

---

[1] Interviews with Safety-Kleen Co., Gray-Mills Co. and Kleer-Flo Co. personnel; these firms are manufacturers of cold solvent metal degreasing equipment.

[2] Based on information in EPA 450/2-77-002, op. cit., and interviews with Baron-Blakeslee and Detrex Chemical personnel.

No reliable data have been found which relate size of cleaner with solvent composition. Therefore, we have assumed a uniform distribution of solvent composition with cleaner size, i.e., the number of small cleaners using exempt solvents is the same as the number of large cleaners using exempt solvents. For instance, the total of affected open top vapor degreasers in the state was determined by multiplying the total number of open top vapor degreasers in the state by the fractions that are nonexempt by solvent use and by size, i.e.:

Number exempt by size = (Total number of open top degreasers) x (Fraction exempt by size, 0.3)

Number exempt by solvent = (Total number of open top degreasers - fraction exempt by size) x (Fraction exempt by solvent, 0.35)

Total number of affected (non-exempt) degreasers = (Total number of open top degreasers) - (Number exempt by size) - (Number exempt by solvent)

The resulting estimate of the total number of degreasers in the state and those exempt from the proposed regulations by size and solvent composition are summarized in Exhibit 11-3, in section 11.2.

11.1.4 Method of Estimation of Number and Type of Retrofitted Controls Needed

The proposed regulations specify certain controls which can be retrofitted to existing solvent metal cleaners. These are discussed in detail in a later section of this chapter. Briefly they are:

- For affected cold cleaners--
    - A cover must be installed when the solvent used has a volatility greater than 15 millimeters of mercury at 38°C, or is agitated, or the solvent is heated; and
    - An internal drainage facility (or, where that is not possible, an external closed drainage facility) must be installed, such that the cleaned parts drain while covered when the solvent used has a volatility greater than 32 millimeters of mercury at 38°C; and

- Where the solvent has a volatility greater than 32 millimeters of mercury at 38°C, a freeboard must be installed that gives a freeboard ratio (i.e., distance from cleaner top to solvent surface divided by cleaner width) greater than or equal to 0.7; or a water cover where the solvent is heavier and immiscible or unreactive with water; or some other system of equivalent control.

- For affected open top vapor degreasers--
  - The vapor degreaser must be equipped with a cover; and
  - A spray safety switch must be installed which shuts off the spray pump when the vapor level drops more than 4 inches; and
  - If the freeboard ratio is greater than 0.75, a powered cover must be installed or a refrigerated chiller; or an enclosure in which a cover or door opens only when the dry part is entering or exiting the degreaser; or a carbon adsorption system; or an equivalent control system.

- For affected conveyorized degreasers--
  - A refrigerated chiller; or carbon adsorption system; or another equivalent control system must be installed; and
  - The cleaner must be equipped with a drying tunnel or rotating basket to prevent cleaned parts from carrying out solvent; and
  - A condenser flow switch and thermostat, a spray safety switch and a vapor high level control thermostat must be installed; and
  - Openings must be minimized during operation so that entrances and exits silhouette workloads; and
  - Downtime covers must be provided for closing off the entrance and exit during shutdown hours.

Exhibits 11-15, 11-16 and 11-17, of this chapter, summarize estimates of the percentage of nonexempt cleaners needing these controls. Equipment manufacturers were the primary source of the percentages used. In applying this information, it was assumed that the number and type of control needed were independent of size.

11.1.5 Method of Estimation of Current Emissions and Expected Reductions

Current VOC emissions from solvent metal degreasing and the reductions anticipated by the enforcement of the proposed regulations are based on information presented in Control of Volatile Organic Emissions from Solvent Metal Cleaning, EPA-450/2-77-022, November 1977. This report estimates average emissions for each type of degreaser. The total current emissions were obtained by multiplying these estimated average emissions by the number of each type of degreaser in the state.

The report also estimates the reduction in emissions possible by implementation of various types of controls. The methods proposed in recent EPA guidelines can result in reduction of 50 percent to 69 percent for various types of degreasers. Emission levels which would result from implementation of the RACT proposals for solvent metal cleaners was obtained by use of these estimated reductions for the number of affected cleaners in the state. For purposes of estimation, a 53 percent reduction was used for cold cleaners. For open top vapor and conveyorized cleaner, a 60 percent reduction was used.

11.1.6 Method of Estimation of Compliance Costs

Compliance costs were based primarily on the cost data presented in the EPA report, Control of Volatile Organic Emissions from Solvent Metal Cleaning, for average-sized, cold, open top vapor and conveyorized cleaners. The cost data, however, were verified by discussions with equipment manufacturers. Where some costs, such as for safety switches or downtime covers, were not estimated in the report, estimates were made based on further discussions with equipment manufacturers. In the report, costs were presented for various retrofit control options; in each case the control which would provide minimum net annualized costs was used. Other costs not presented in the EPA report were determined as follows:

- Capital costs for safety switches, minimizing conveyorized cleaner openings and downtime covers were estimated on the basis of discussions with equipment manufacturers. Costs used were:
  - $275 per manual cover and $100 per safety switch installation for open top vapor degreasers
  - $250 per safety switch installation, $300 per downtime cover installation, $2,500 per drying tunnel and $1,000 for reducing openings for conveyorized cleaners.
- An average of $300 was estimated as the cost to increase freeboard of cold cleaners using high volatility solvents.
- Additional annual capital charges were estimated as 25 percent of capital costs, to include depreciation, interest, maintenance, insurance and administrative costs.
- Labor costs for mounting downtime covers on conveyorized cleaners at shift end were estimated at $1,500 per year per cleaner.
- Additional costs which might result from decreased productivity, labeling and other requirements of the proposed regulations were assumed to be small and negligible.

11.1.7 Quality of Estimates

Several sources of information were utilized in assessing the emissions, direct compliance cost and economic impact of implementing RACT controls on plants using solvent metal degreasers in Michigan. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year), "B" indicates data that were not available in secondary literature and were extrapolated from hard data and "C" indicates data were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 11-1A, on the following page, rates each study output and overall quality of the data.

EXHIBIT 11-1A
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A "Hard Data"	B "Extrapolated Data"	C "Estimated Data"
Industry statistics	X	X	
Emissions		X	
Cost of emissions control		X	X
Statewide costs of emissions			X
Overall quality of data		X	

Source: Booz, Allen & Hamilton Inc.

11.2 INDUSTRY STATISTICS

This section summarizes an estimation of the total number of solvent metal cleaners in the state determined by the methods discussed in section 11.1.2 of this report. As shown in Exhibits 11-1 and 11-2, on the following pages, a total of 1,111 open top vapor degreasers, 262 conveyorized degreasers and 68,200 cold cleaners are estimated to be in use in Michigan in manufacturing, maintenance and service. As discussed earlier, not all of these will be subject to RACT regulations because of size or solvent exemptions. About 30 percent of open top vapor degreasers, 5 percent of conveyorized degreasers and 70 percent of cold cleaners are expected to be exempt on the basis of size. About 35 percent of open top vapor degreasers, 10 percent of conveyorized degreasers and 20 percent of cold cleaners are expected to be exempt because they use exempt solvents 1,1,1-trichloroethane or Freon 113. Applying these factors results in the total of affected cleaners shown in Exhibit 11-3, following Exhibit 11-2.

It is difficult to estimate the number of establishments affected by the regulations, since a plant may have one or many cleaners of each type. In fact, large-scale users may have more than 100 degreasing operations in one plant location. Metal working industries would be major users; eight SIC codes, 25 and 33-39, cover these industries.

These classifications include such industries as automotive, electronics, appliances, furniture, jewelry, plumbing, aircraft, refrigeration, business machinery and fasteners. However, use of solvent cleaning is not limited to those industries, since many cleaners are used, for both manufacturing and maintenance, in nonmetal working industries such as printing, chemicals, plastics, rubber, textiles, paper and electric power. Also, most automotive, railroad, bus, aircraft, truck and electric motor repair stations use metal solvent cleaners at least part time.

As shown in Exhibit 11-1, 761 establishments in the SIC codes 25 and 33-39, with more than 19 employees are estimated to use solvent metal degreasing. In addition, approximately 8,000 firms in service industries also are estimated to do solvent metal degreasing.

EXHIBIT 11-1 (1)
U.S. Environmental Protection Agency

ESTIMATED NUMBER OF VAPOR DEGREASERS IN MICHIGAN[e]

Item	SIC GROUP 25 Metal Furniture	 33 Primary Metals	 34 Fabricated Products	 35 Nonelectrical Machinery	 36 Electrical Equipment	 37 Transptn. Equipment	 38 Instruments and clocks	 39 Misc. Industry	Total
Number of Michigan plants with more[a] than 19 employees	117	302	897	1,035	186	300	79	83	2,999
Percent of U.S. plants using solvent degreasing[b]	46	40	42	52	55	50	65	39	
Percent of Michigan plants using solvent degreasing	45	39	41	51	54	49	64	38	
Number of Michigan plants using solvent degreasing	53	118	368	528	100	147	50	32	1,396
Percent of U.S. plants using vapor degreasing	48	42	41	33	67	43	62	56	
Percent of Michigan plants using vapor degreasing	46	40	39	31	64	41	59	53	
Number of Michigan plants using vapor degreasing	24	47	144	164	64	60	29	17	549
Average number of vapor degreasers per U.S. plant	1.98	2.21	1.62	1.61	2.03	3.25	2.27	1.02	
Average number of vapor degreasers per Michigan plant	1.85	2.06	1.51	1.50	1.89	3.03	2.12	0.95	
Number of vapor degreasers in Michigan	44	97	217	246	121	182	61	16	984

EXHIBIT 11-1 (2)
U.S. Environmental Protection Agency
(Michigan)

Item	25 Metal Furniture	33 Primary Metals	34 Fabricated Products	35 Nonelectrical Machinery	36 Electrical Equipment	37 Transptn. Equipment	38 Instruments and clocks	39 Misc. Industry	Total
	SIC GROUP								
Percent in U.S. as open top degreasers	74	79	79	81	87	87	94	89	
Percent in Michigan as open top degreasers	69	74	74	76	81	81	88	83	
Number of open top vapor degreasers in Michigan	30	72	160	187	98	147	54	13	761[c]
Number of conveyorized vapor degreasers in Michigan	14	25	57	59	23	35	7	3	223[d]

Note: All data based on plants with more than 19 employees

a. Source: County Business Patterns, U.S. Dept. of Commerce, 1976

b. Source of data on percentage of plants solvent degreasing, those with open top or conveyorized vapor degreasers and average numbers of degreasers per plant: Study to Support New Source Performance Standards for Solvent Metal Cleaning Operations, Dow Chemical Company under EPA Contract 68-02-1329, June 30, 1976

c. To adjust quantities to account for vapor degreasers in other SIC groups multiply by the factor (22,200/15,200), the ratio of all open top vapor degreasers in U.S. to open top vapor degreasers in metal working SIC groups.

d. To adjust quantities to include cold conveyorized cleaners, multiply by 100/85, since conveyorized vapor cleaners are estimated to represent 85 percent of all conveyorized cleaners.

e. Number of degreasers rounded to the nearest whole integer.

So[illegible]: [illegible], A[illegible] & [illegible]ltor[illegible]. [illegible]sis [illegible] Dep[illegible]ent [illegible] Com[illegible]e a[illegible] EPA [illegible]rts

EXHIBIT 11-2
U.S. Environmental Protection Agency
ESTIMATED NUMBERS OF COLD CLEANERS IN MICHIGAN

	U.S.	Michigan
Total number of plants in SIC Groups 25,33,34,35,36,37,38,39 (a)	125,271	8,147
Estimated number of cold cleaners in manufacturing (b)	390,000	25,400
Total number of plants in service industries 551,554,557,7538,7539,7964 (a)	227,350	8,425
Estimated number of cold cleaners in maintenance and service use (b)	910,000	42,800
Estimated total number of cold cleaners (b)	1,300,000	68,200

Notes:

a. Source: 1976 County Business Patterns, U.S. Department of Commerce, 1976.

b. Source: Control of Volatile Organic Emissions From Solvent Metal Cleaning, EPA-450/2-77-022, November 1977; this includes those cold cleaners in maintenance and service applications by both manufacturing and repair firms.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 11-3
U.S. Environmental Protection Agency
ESTIMATE OF NONEXEMPT SOLVENT METAL
CLEANERS IN MICHIGAN

	Number of Cleaners by Type		
Exemption	Cold[a]	Open Top Vapor	Conveyorized
Total number of cleaners	68,200	1,111	262
Number exempt by size	47,800	333	14
Number nonexempt by size	20,400	778	248
Number further exempted by type of solvent used	4,100	272	25
Total number of affected cleaners	16,300	506	223

---

[a] Numbers rounded to the nearest 100 units.

Source: Booz, Allen & Hamilton Inc.

11.3 THE TECHNICAL SITUATION IN THE INDUSTRY

11.3.1 Solvent Metal Cleaning Processes[1]

Solvent metal cleaning describes those processes using nonaqueous solvents to clean and remove soils from metal surfaces. These solvents, which are principally derived from petroleum, include petroleum distillates, chlorinated hydrocarbons, ketones and alcohols. Organic solvents, such as these, can be used alone or in blends to remove water-insoluble soils for cleaning purposes and to prepare parts for painting, plating, repair, inspection, assembly, heat treatment or machining.

A broad spectrum of organic solvents is available. Choices among the solvents are based on the solubility of the soil, toxicity, flammability, evaporation rate, effect on nonmetallic portions of the part cleaned and numerous other properties. Exhibit 11-4, on the following page, lists solvents normally used in solvent degreasing.

The cleaning techniques can be broken down into two categories: cold cleaning and vapor degreasing. In cold cleaning, parts are dipped, sprayed, brushed or wiped with solvents at or near room temperature. In vapor degreasing, cold parts are suspended in a solvent vapor which condenses on the parts and dissolves greases and other soils.

Typically, the cleaning process is done in one of three types of cleaners or degreasers:

- A cold cleaner
- An open top vapor degreaser
- A conveyorized degreaser.

---

[1] The descriptive and other information in this section has been obtained from Control of Volatile Organic Emissions from Solvent Metal Cleaning (EPA-450/2-77-022, November, 1977). This document should be consulted for a more detailed description of the techniques and devices used for solvent degreasing.

EXHIBIT 11-4

U.S. Environmental Protection Agency

SOLVENTS CONVENTIONALLY USED IN SOLVENT METAL DEGREASING

General Type	Solvent
Alcohols	Ethanol (95%)
	Isopropanol
	Methanol
Alipatic hydrocarbons	Heptane
	Kerosene
	Stoddard
	Mineral spirits 66
Aromatic hydrocarbons	Benzene
	SC 150
	Toluene
	Turpentine
	Xylene
Chlorinated solvents	Carbon tetrachloride
	Methylene chloride
	Perchloroethylene
	1, 1, 1-Trichloroethane
	Trichloroethylene
Fluorinated solvents	Trichlorotrifluoroethane (FC-113)
Ketones	Acetone
	Methyl ethyl ketone

11.3.1.1 Cold Cleaners

Cold cleaner operations include spraying, brushing, flushing and immersion. The solvent occasionally is heated in cold cleaners but always remains well below its boiling point.

Cold cleaners are estimated to result in the largest total emission of the three categories of degreasers. This is primarily because there are so many of these units (more than 1 million nationally) and because much of the waste solvent that is disposed of is allowed to evaporate. It is estimated that cold cleaners emit 420,000 short tons of organics per year, this being about 55 percent of the national degreasing emissions. Cold cleaning solvents nationally account for almost all of the aliphatic, aromatic and oxygenated degreasing solvents and about one-third of halogenated degreasing solvents.

Despite the large aggregate emission, the average cold cleaning unit generally emits only about one-third ton per year of organics, with about one-half to three-fourths of that emission resulting from evaporation of the waste solvent at a disposal site.

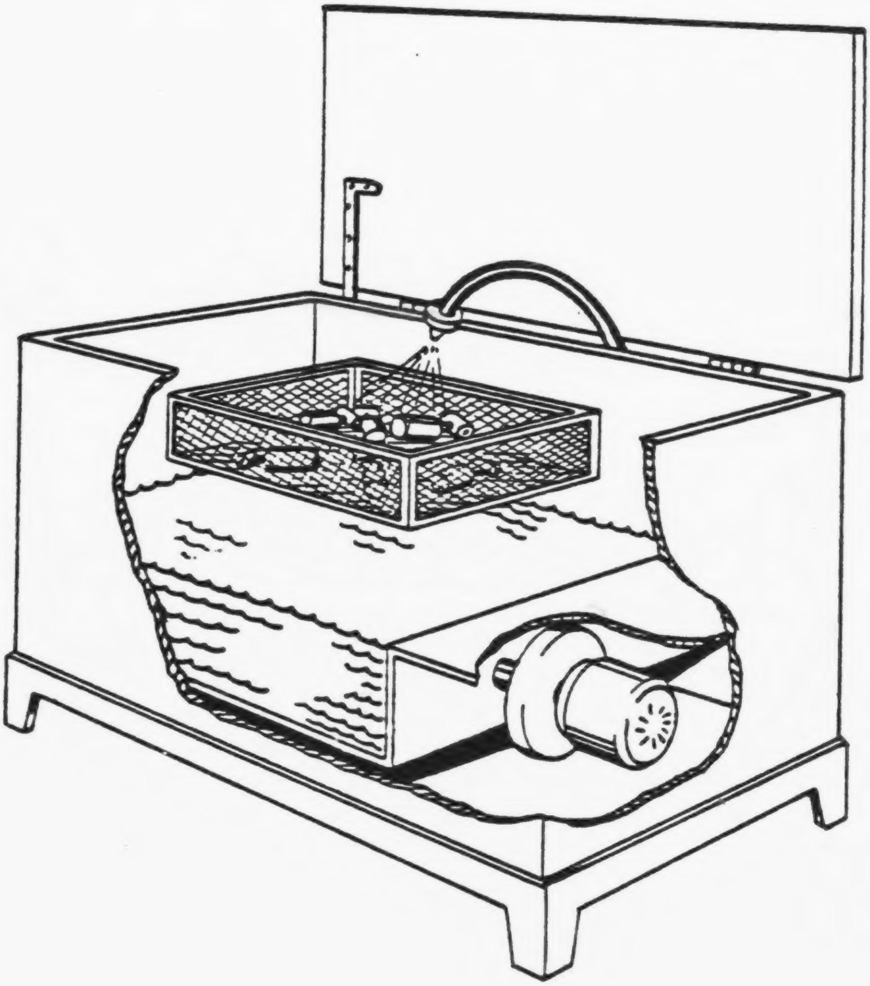
In a typical cold cleaner (Figure 11-1, on the following page), dirty parts are placed in a basket and are cleaned manually by spraying or soaking in a dip tank. The solvent in this dip tank is often agitated to enhance the cleaning action. After cleaning, the basket of cleaned parts may be suspended over the solvent to allow the parts to drain, or the cleaned parts may be drained on an external drainage rack which routes the drained solvent back into the cleaner. The cover should be closed whenever parts are not being handled in the cleaner. Typically, a maintenance cold cleaner has about 0.4 m^2 (4 $ft.^2$) of opening and about 0.1 m^3 (30 gallon) capacity.

The two basic types of cold cleaners are maintenance cleaners and manufacturing cleaners. The maintenance cold cleaners are usually simpler, less expensive and smaller. They are designed principally for automotive and general plant maintenance cleaning.

Manufacturing cold cleaners usually give a higher quality of cleaning than maintenance cleaners do, and are thus more specialized. Manufacturing cold cleaning is generally an integral stage in metal working production. There are fewer manufacturing cold cleaners than maintenance cleaners, but the former tend to emit more solvent per unit because of the larger

FIGURE 11-1
U.S. Environmental Protection Agency
TYPICAL COLD CLEANER

SPRAY CLEANING EQUIPMENT



Source: EPA 450/2-77-022

size and workload. Manufacturing cleaners use a wide variety of solvents, whereas maintenance cleaners use mainly petroleum solvents such as mineral spirits (petroleum distillates and Stoddard solvents). Some cold cleaners can serve both maintenance and manufacturing purposes and thus are difficult to classify.

11.3.1.2 Open Top Vapor Degreasers

Vapor degreasers clean through the condensation of hot solvent vapor on colder metal parts. Open top vapor degreasers are batch loaded, i.e., they clean only one workload at a time.

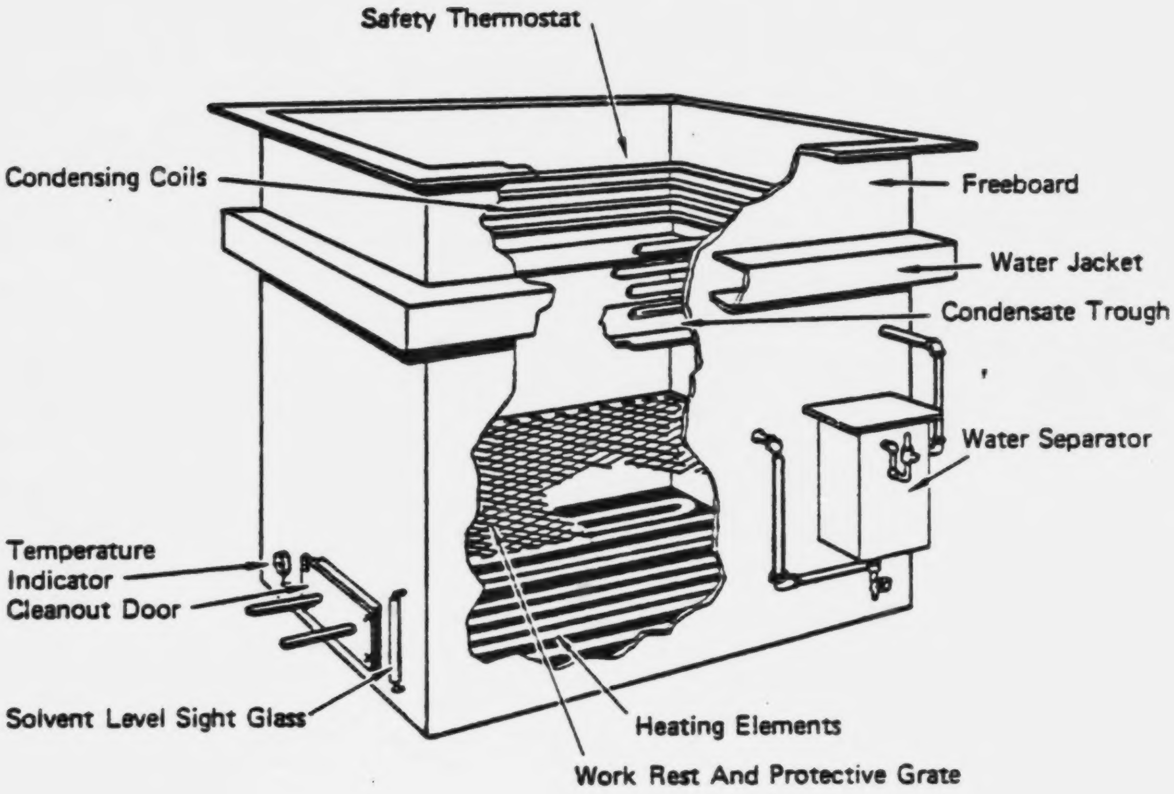
Open top vapor degreasers are estimated to result in the second largest emission of the three categories of degreasers. It is estimated that open top vapor degreasers emit 220,000 short tons of organic per year, this being about 30 percent of the national degreasing emissions.

In the vapor degreaser, solvent vapors condense on the parts to be cleaned until the temperature of the parts approaches the boiling point of the solvent. The condensing solvent both dissolves oils and provides a washing action to clean the parts. The selected solvents boil at much lower temperatures than do the contaminants; thus, the solvent/soil mixture in the degreaser boils to produce an essentially pure solvent vapor.

The simplest cleaning cycle involves lowering the parts into the vapor zone so that the condensation action can begin. When condensation ceases, the parts are slowly withdrawn from the degreaser. Residual liquid solvent on the parts rapidly evaporates as the parts are removed from the vapor zone. The cleaning action is often increased by spraying the parts with solvent (below the vapor level) or by immersing them into the liquid solvent bath.

A typical vapor degreaser, shown in Figure 11-2, on the following page, is a tank designed to produce and contain solvent vapor. At least one section of the tank is equipped with a heating system that uses steam, electricity or fuel combustion to boil the solvent. As the solvent boils, the dense solvent vapors displace the air within the equipment. The upper level of these pure vapors is controlled by condenser coils located on the sidewalls of the degreaser. These coils, which are supplied with a coolant such as water, are generally located around the entire inner surface of the degreaser, although for some smaller equipment they are limited to a spiral coil at one end of the degreaser. Most vapor degreasers are also equipped with a water jacket which provides additional cooling and prevents convection of solvent vapors up hot degreaser walls.

FIGURE 11-2
U.S. Environmental Protection Agency
TYPICAL OPEN TOP VAPOR DEGREASER



OPEN TOP DEGREASER

Safety Thermostat
Condensing Coils
Freeboard
Water Jacket
Condensate Trough
Water Separator
Temperature Indicator
Cleanout Door
Solvent Level Sight Glass
Heating Elements
Work Rest And Protective Grate

Source: EPA 450/2-77-022

The cooling coils must be placed at some distance below the top edge of the degreaser to protect the solvent vapor zone from disturbance caused by air movement around the equipment. This distance from the top of the vapor zone to the top of the degreaser tank is called the freeboard and is generally established by the location of the condenser coils.

Nearly all vapor degreasers are equipped with a water separator, such as that depicted in Figure 11-2. The condensed solvent and moisture are collected in a trough below the condenser coils and directed to the water separator. The water separator is a simple container which allows the water (being immiscible and less dense than solvents) to separate from the solvent and decant from the system while the solvent flows from the bottom of the chamber back into the vapor degreaser.

11.3.1.3 Conveyorized Degreaser

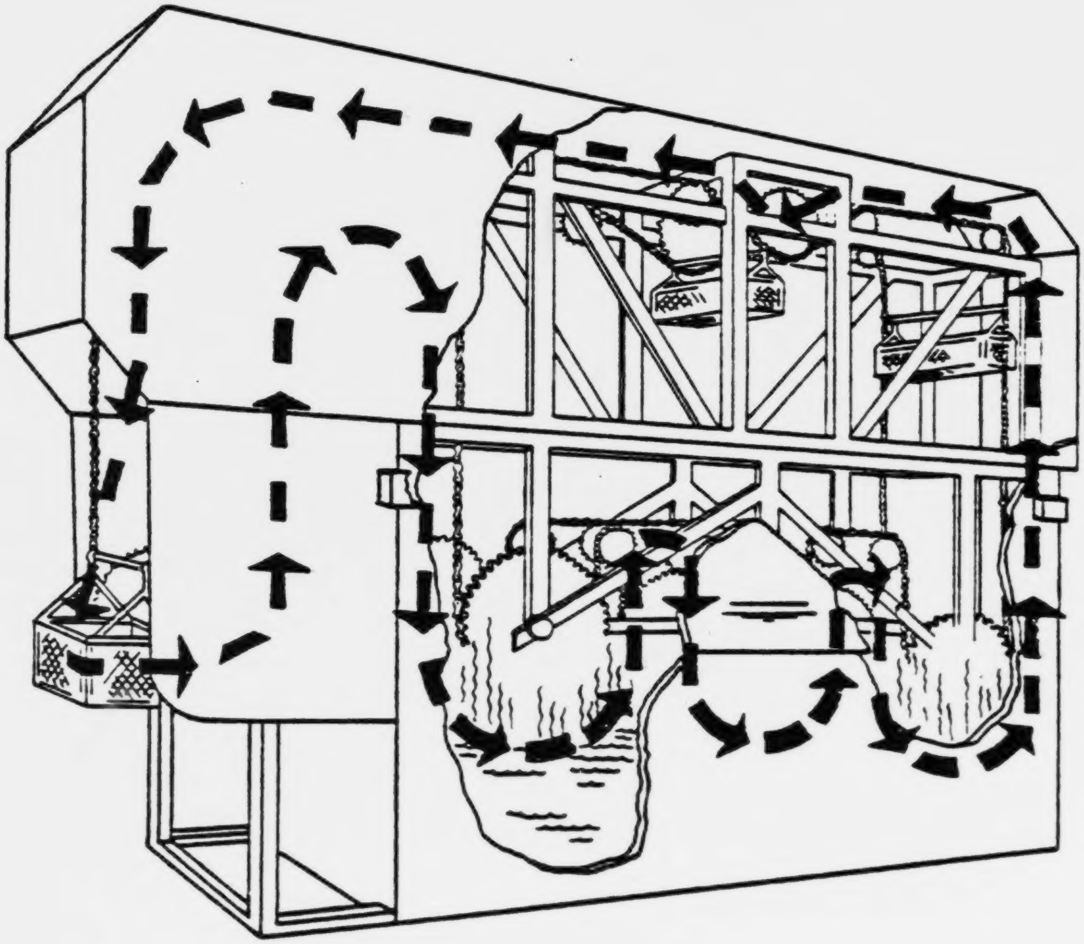
There are several types of conveyorized degreasers, operating both with cold and with vaporized solvents. An average conveyorized degreaser emits about 25 metric tons per year of solvent; however, because of their limited numbers, these degreasers contribute only about 15 percent of the total solvent degreasing emissions. Because of their large work capacity, conveyorized degreasers actually emit less solvent per part cleaned than either open top vapor degreasers or cold cleaners.

In conveyorized equipment, most, and sometimes all, of the manual parts handling associated with open top vapor degreasing has been eliminated. Conveyorized degreasers are nearly always hooded or covered. The enclosure of a degreaser diminishes solvent losses from the system as the result of air movement within the plant. Conveyorized degreasers are used by a broad spectrum of metal working industries but are most often found in plants where there is enough production to provide a constant stream of products to be degreased.

There are a number of types of conveyorized degreasers employing various techniques of conveying the parts, either through a pool or spray of cold cleaning solvents or through a space containing vaporized solvent. A cross-rod degreaser (Figure 11-3, on the following page) illustrates the general concepts of operation of the various types of conveyorized degreasers.

FIGURE 11-3
U.S. Environmental Protection Agency
TYPICAL CONVEYORIZED DEGREASER

CROSS-ROD CONVEYORIZED DEGREASER



Source: EPA 450/2-77-022

The cross-rod degreaser obtains its name from the rods between the two power driven chains from which parts are supported as they are conveyed through the equipment. The parts are contained in pendant baskets or, where tumbling of the parts is desired, perforated cylinders. These cylinders are rotated by a rack and pinion design within the solvent and/or the vapor zone. This type of equipment lends itself particularly well to handling small parts which need to be immersed in solvent to obtain satisfactory cleaning or require tumbling to provide drainage from cavities in the parts.

Other types of conveyorized degreasers similarly use rotating wheels, conveyor belts, monorail or other systems to convey the parts through the degreasing medium.

11.3.2 Proposed Emission Control Systems for Solvent Metal Cleaners

The EPA has proposed two different emission control methods, A and B, for each of the three types of cleaners: cold, open top vapor and conveyorized. The control methods can be combined in various ways to form a number of alternative control systems. Generally, control system A consists of proper operating practices and simple, inexpensive control equipment. Control system B consists of system A plus other devices that increase the effectiveness of control. Elements of control systems A or B can be modified to arrive at the level of control needed. The control systems are presented in the three exhibits, Exhibit 11-5, 6 and 7, on the following pages, and are briefly discussed below. In general, use of control system B has been proposed to maximize emission reductions.

11.3.2.1 Cold Cleaning Control Systems

The most important emission control for cold cleaners is the control of waste solvent. The waste solvent needs to be reclaimed or disposed of so that a minimum evaporates into the atmosphere. Next in importance are the operating practices of closing the cover and draining cleaned parts. Several other control techniques become significant only in a small fraction of applications.

The difference in effect between systems A and B (Exhibit 11-5) is not large because most of the cold cleaning emissions are controlled in system A. If the requirements of system A

EXHIBIT 11-5
U.S. Environmental Protection Agency
CONTROL SYSTEMS FOR COLD CLEANING

Control System A

Control Equipment:

1. Cover
2. Facility for draining cleaned parts
3. Permanent, conspicuous label, summarizing the operating requirements

Operating Requirements:

1. Do not dispose of waste solvent or transfer it to another party, such that greater than 20 percent of the waste (by weight) can evaporate into the atmosphers.* Store waste solvent only in covered containers.

2. Close degreaser cover whenever not handling parts in the cleaner.

3. Drain cleaned parts for at least 15 seconds or until dripping ceases.

Control System B

Control Equipment:

1. Cover: Same as in System A, except if (a) solvent volatility is greater than 2 Kpa (15 mm Hg or 0.3 psi) measured at 38°C (100°F),** (b) solvent is agitated, or (c) solvent is heated, then the cover must be designed so that it can be easily operated with one hand. (Covers for larger degreasers may require mechanical assistance, by spring loading, counterweighting or powered systems.)

2. Drainage facility: Same as in System A, except that if solvent volatility is greater than about 4.3 Kpa (32 mm Hg or 0.6 psi) measured at 38° C (100°F), then the drainage facility must be internal, so that parts are enclosed under the cover while draining. The drainage facility may be external for applications where an internal type cannot fit into the cleaning system.

3. Label: Same as in System A

4. If used, the solvent spray must be solid, fluid stream (not a fine, atomized or shower type spray) and at a pressure which does not cause excessive splashing.

5. Major control device for highly volatile solvents: If the solvent volatility is 4.3 Kpa (33 mm Hg or 0.6 psi) measured at 38°C (100°F), or if solvent is heated about 50°C (120°F), then one of the following control devices must be used:

   a. Freeboard that gives a freeboard ratio*** 0.7

   b. Water cover (solvent must be insoluble in and heavier than water)

   c. Other systems of equivalent control, such as refrigerated chiller or carbon absorption.

Operating Requirements:

Same as in System A

---

* Water and solid waste regulations must also be complied with

** Generally solvents consisting primarily of mineral spirits (Stoddard) have volatilities 2 Kpa.

*** Freeboard ratio is defined as the freeboard height divided by the width of the degreaser.

Source: Booz. Allen & Hamilton Inc.

EXHIBIT 11-6(1)
U.S. Environmental Protection Agency
EPA PROPOSED CONTROL SYSTEMS FOR OPEN TOP VAPOR DEGREASERS

Control System A

Control Equipment:

1. Cover that can be opened and closed easily without disturbing the vapor zone.

Operating Requirements:

1. Keep cover closed at all times except when processing work loads through the degreaser.
2. Minimize solvent carry-out by the following measures:

a. Rack Parts to allow full drainage.
b. Move parts in and out of the degreaser at less than 3.3 m/sec (11 ft/min).
c. Degrease the work load in the vapor zone at least 30 sec. or until condensation ceases.
d. Tip out any pools of solvent on the cleaned parts before removal.
e. Allow parts to dry within the degreaser for at least 15 sec. or until visually dry.

3. Do not degrease porous or absorbent materials, such as cloth, leather, wood or rope.
4. Work loads should not occupy more than half of the degreaser's open top area.
5. The vapor level should not drop more than 10 cm (4 in) when the work load enters the vapor zone.
6. Never spray above the vapor level.
7. Repair solvent leaks immediately, or shutdown the degreaser.
8. Do not dispose of waste solvent or transfer it to another party such that greater than 20 percent of the waste (by weight) will evaporate into the atmosphere. Store waste solvent only in closed containers.
9. Exhaust ventilation should not exceed 20 m^3/min per m^2 (65 cfm per ft^2) of degreaser open area, unless necessary to meet OSHA requirements. Ventilation fans should not be near the degreaser opening.
10. Water should not be visually detectable in solvent exiting the water separator.

Control System B

Control Equipment:

1. Cover (same as in system A).
2. Safety switches

a. Condenser flow switch and thermostat - (shuts off sump heat if condenser coolant is either not circulating or too warm).
b. Spray safety switch - shuts off spray pump if the vapor level drops excessively, about 10 cm (4 in).

EXHIBIT 11-6 (2)
U.S. Environmental Protection Agency

3. Major Control Device:

Either: a. Freeboard ratio greater than or equal to 0.75, and if the degreaser opening is 1 m^2 (10 ft^2), the cover must be powered,

b. Refrigerated chiller,

c. Enclosed design (cover or door opens only when the dry part is actually entering or exiting the degreaser.),

d. Carbon adsorption system, with ventilation 15 m^3/min per m^2 (50 cfm/ft^2) or air/vapor area (when cover is open), and exhausting 25 ppm solvent averaged over one complete adsorption cycle, or

e. Control system, demonstrated to have control efficiency, equivalent to or better than any of the above.

4. Permanent, conspicuous label, summarizing operating procedures #1 to #6.

Operating Requirements:

Same as in System A.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 11-7

U.S. Environmental Protection Agency

EPA PROPOSED CONTROL SYSTEMS FOR CONVEYORIZED DEGREASERS

Control System A

Control Equipment: None

Operating Requirements:

1. Exhaust ventilation should not exceed 20 m^3/min per m^2 (65 cfm per ft^2) of degreaser opening, unless necessary to meet OSHA requirements. Work place fans should not be used near the degreaser opening.

2. Minimize carry-out emissions by:

a. Racking parts for best drainage.
b. Maintaining verticle conveyor speed at 3.3 m/min (11 ft/min).

3. Do not dispose of waste solvent or transfer it to another party such that greater than 20 percent of the waste (by weight) can evaporate into the atmosphere. Store waste solvent only in covered containers.

4. Repair solvent leaks immediately, or shutdown the degreaser.

5. Water should not be visibly detectable in the solvent exiting the water separator.

Control System B

1. Major control devices; the degreaser must be controlled by either:

a. Refrigerated chiller,
b. Carbon adsorption system, with ventilation 15 m^2/min per m^2 (50 cfm/ft^2) of air/vapor area (when down-time covers are open), and exhausting 25 ppm of solvent by volume averaged over a complete adsorption cycle, or
c. System demonstrated to have control efficiency equivalent to or better than either of the above.

2. Either a drying tunnel, or another means such as rotating (tumbling) basket, sufficient to prevent cleaned parts from carrying out solvent liquid or vapor.

3. Safety switches

a. Condenser flow switch and thermostat - (shuts off sump heat if coolant is eiter not circulating or too warm).
b. Spray safety switch - (shuts off spray pump or conveyor if the vapor level drops excessively, e.g. 10 cm (4 in.)).
c. Vapor level control thermostat - (shuts off sump heat when vapor level rises too high).

4. Minimized openings: Entrances and exits should silhouette work loads so that the average clearance (between parts and the edge of the degreaser opening) is either 10 cm (4 in.) or 10 percent of the width of the opening.

5. Down-time covers: Covers should be provided for closing off the entrance and exit during shutdown hours.

Operating Requirements:

1. to 5. Same as the System A

6. Down-time cover must be placed over entrances and exits of conveyorized degreasers immediately after the conveyor and exhaust are shutdown and removed just before they are started up.

Source: Booz, Allen & Hamilton Inc.

were followed conscientiously by nearly all of the cold cleaning operators, there would be little need for the additional system B requirements. However, because cold cleaning operators tend to be lax in keeping the cover closed, equipment requirements #1 and #4 in system B are added. Similarly, the modifications for #2 and the equipment requirements in #3 would effect significant emission reductions in a few applications.

The effectiveness of the control systems depends greatly on the quality of operation. On the average, system A is estimated to be able to reduce cold cleaning emissions by 50 (± 20) percent and system B may reduce it by 53 (± 20) percent. The low end of the range represents the emission reduction projected for poor compliance, and the high end represents excellent compliance. The expected benefit from system B is only slightly better than that for system A for an average cold cleaner because the additonal devices required in system B generally control only bath evaporation, about 20 to 30 percent of the total emission from an average cold cleaner. For cold cleaners with high volatility solvents, bath evaporation may contribute about 50 percent of the total emission; EPA estimates that system B could achieve 69 (± 20) percent control efficiency, whereas system A might achieve only 55 (±20) percent.

11.3.2.2 Open Top Vapor Degreasing Control Systems

The basic elements of a control system for open top vapor degreasers are proper operating practices and use of control equipment. There are about ten main operating practices. The control equipment includes a cover, safety switches and a major control device, either high freeboard, refrigerated chiller, enclosed design or carbon adsorption as outlined in Exhibit 11-6.

A vapor level thermostat is not included because it is already required by OSHA on "open surface vapor degreasing tanks." Sump thermostats and solvent level controls are used primarily to prevent solvent degradation and protect the equipment and thus are also not included here. The emission reduction by these controls is a secondary effect in any event. The two safety switches serve primarily to reduce vapor solvent emissions.

EPA estimates that system A may reduce open top vapor degreasing emissions by 45 (±15) percent, and system B by 60 (±15) percent. For an average-sized open top vapor degreaser, systems A and B would reduce emissions from 9.5 m tons/year down to about 5.0 and 3.8 m tons/year, respectively. It is clear that system B is appreciably more effective than system A.

11.3.2.3 Conveyorized Degreasing Control Systems

Control devices tend to work most effectively on conveyorized degreasers, mainly because they are enclosed. Since these control devices can usually result in solvent savings, they often will net an annualized profit. Two control systems for conveyorized degreasers as recommended by EPA are in Exhibit 11- 7. Control system A requires only proper operating procedures which can be implemented, in most cases, without large capital expenditures. Control system B, on the other hand, requires a major control device.

Major control devices can provide effective and economical control for conveyorized degreasers. A refrigerated chiller will tend to have a high control efficiency, because room drafts generally do not disturb the cold air blanket. A carbon adsorber also tends to yield a high control efficiency, because collection systems are more effective and inlet streams contain higher solvent concentrations for conveyorized degreasers than for open top vapor degreasers.

11.3.3 Emissions and Expected Emission Reduction

In Exhibit 11-8, on the following page, are summarized the average emissions from solvent metal degreasers by type and also the percent emission reduction expected by implementation of Type B method of controls on nonexempt degreasers. The levels are based on estimated emissions as presented in the previously referenced EPA report (EPA 450/2-77-022) and represent current average emission levels and expected reductions achievable if emission controls are rigorously enforced. For estimation, 50 percent reduction was used for cold cleaners and 60 percent for open top vapor and conveyorized degreasers.

Exhibit 11-9, following Exhibit 11-8, presents the estimated current emissions from solvent metal degreasing and the expected emissions if the B methods of control are implemented for metal cleaners and proposed exemptions for size and type of solvent are implemented. As shown, emissions are expected to be reduced from about 42,500 short tons per year to a total of 33,400 short tons per year. The major portion of these reduced emissions, 26,400 tons, are from solvent metal cleaners exempt from the proposed RACT regulations either by size or by the nature of solvent used. Implementation of the regulations will reduce emissions only by 9,100 short tons per year (42,500 minus 33,400).

EXHIBIT 11-8
U.S. Environmental Protection Agency
AVERAGE UNIT EMISSION RATES AND EXPECTED EMISSION REDUCTIONS

EMISSION RATES WITHOUT CONTROLS

Type of Degreaser	Averaged Emission Rate Per Unit (short tons/yr.)
Cold cleaners, batch [a]	0.33
Open top vapor degreaser	11.00
Conveyorized degreaser	29.70

PERCENT EMISSION REDUCTION EXPECTED WITH TYPE B CONTROLS

Type of Degreaser	Percent Emission Reduction Expected
Cold cleaner, batch	
Low volatility solvents	53 (± 20)
High volatility solvents	69 (± 20)
Open top vapor degreaser	60 (± 15)
Conveyorized degreaser	60 (± 15)

---

[a] Does not include emissions from conveyorized-type cold cleaners which represent about 15 percent of all conveyorized cleaners.

Source: EPA-450/2-77-022, op. cit.

EXHIBIT 11-9

U.S. Environmental Protection Agency

ESTIMATED CURRENT AND REDUCED EMISSIONS FROM SOLVENT METAL CLEANING IN MICHIGAN

(Tons/year)

Type of Cleaner	Estimated Current Emissions	Current Emissions From Affected Cleaners	Estimated From Affected Cleaners After RACT	Estimated Emissions From Exempt Cleaners After RACT[a]	Estimated Total Emissions After RACT[a]
Open top vapor	12,200	5,500	2,200	6,700	8,900
Conveyorized	7,800	6,600	2,600	1,200	3,800
Cold	22,500	5,400	2,700	17,100	19,800
Total	42,500	17,500	7,500	25,000	32,500

---

[a] Includes emissions from cleaners exempt by size or using 1,1,1-trichloroethane or Freon 113

Source: Booz, Allen & Hamilton, Inc.

11.4 ESTIMATED COSTS OF RACT IMPLEMENTATION

As discussed in Section 11.1.6 compliance costs are based upon EPA estimates of the costs and benefits of various retrofitted methods of control. These estimates are summarized in Exhibits 11-10 and 11-11 on the following pages.

Costs of implementation of the RACT regulations are summarized in Exhibits 11-12, 11-13 and 11-14, on the assumption that control methods B are used to maximize emission reduction on nonexempt cleaners. Exhibits 11-15, 11-16, and 11-17 summarize the number and type of controls needed by cleaner type as determined from interviews with cleaner manufacturers. Total expenditures for all cleaners, vapor and cold types, are estimated to be about $5.9 million in capital and about $0.68 million in net annualized costs. The low net annualized costs result primarily from the savings in solvent use which the regulations are expected to provide.

In most cases the regulations are not expected to present a financial burden to individual firms. The largest single expenditure would be for retrofitting a monorail conveyorized degreaser with chiller, switches, drying tunnel, reduced openings and downtime covers. Total cost for an average-sized degreaser of about 3.8 square meters area (40.9 ft^2) would be less than $12,500. A large unit, 14 square meters, would cost about $27,000 to $30,000. Since these conveyorized systems would only be used in large plants with large sales volumes, this implementation costs is not expected to present a hardship to any particular firms. There may be a few marginally profitable firms, however, which may find access to capital difficult. The number of such firms is anticipated to be small.

EXHIBIT 11-10
U.S. Environmental Protection Agency
CONTROL COSTS FOR COLD CLEANER
WITH 5.25 Ft.^{2} AREA

Item	Low Volatility Solvent[a]	High Volatility Solvent[b]
Installed capital ($)	25.00	365
Direct operating costs ($/yr.)	1.00	2.60
Capital charges ($/yr.)[c]	6.25	91.25
Solvent cost (credit) ($/yr.)	(4.80)	(39.36)
Annualized cost (credit) ($/yr.)	2.45	54.49

---

[a] Costs include only a drainage facility for low volatility solvents.

[b] Includes $65 for drainage facility, a mechanically assisted cover and extension of freeboard.

[c] Capital charges used in study estimates were 25 percent of capital instead of 17 percent used in EPA report.

Source: EPA-450/2-77-022, op. cit.

EXHIBIT 11-11
U.S. Environmental Protection Agency
CONTROL COSTS FOR AVERAGE-SIZED OPEN TOP VAPOR AND CONVEYORIZED CLEANERS

1. CONTROL COSTS FOR TYPICAL SIZE OPEN TOP VAPOR DEGREASER
(Vapor to Air Area of 1.67 m^2)

Control Technique	Manual Cover	Carbon Adsorption[a]	Refrigerated Chiller	Extended Freeboard & Powered Cover
Installed capital ($)	300	10,300	6,500	8,000
Direct operating cost ($/yr.)	10	451	259	100
Capital charges ($/yr.)[b]	75	2,575	1,625	2,000
Solvent cost (credit) ($/yr.)	(860)	(1,419)	(1,290)	(1,161)
Net annualized cost (credit) ($/yr.)	(775)	1,607	594	939

2. CONTROL COSTS FOR TYPICAL CONVEYORIZED DEGREASERS
(Vapor to Air Vapor Area of 3.8 m^2)

	Monorail Degreaser		Crossrod Degreaser	
Control Technique	Carbon[a] Adsorber	Refrigerated Chiller	Carbon[a] Adsorber	Refrigerated Chiller
Installed capital ($)	17,600	8,550	17,600	7,460
Direct operating costs ($/yr.)	970	430	754	334
Capital charges ($/yr.)	4,400	2,138	4,400	1,865
Solvent cost (credit) ($/yr.)	(5,633)	(5,633)	(2,258)	(2,258)
Net annualized cost (credit) ($/yr.)	(263)	(3,065)	2,896	(59)

---

[a] Not used in cost estimates since net annualized costs for carbon absorption are the highest for any control method.

[b] Capital charges used in study estimate were 25 percent of capital instead of 17 percent used by EPA source.

Source: EPA 450/2-77-022, op. cit.

EXHIBIT 11-12
U.S. Environmental Protection Agency
ESTIMATED CONTROL COSTS FOR COLD CLEANERS FOR THE STATE OF MICHIGAN

1. CAPITAL COSTS

Item	Number of Degreasers Needing Conversion	Costs[a]
Capital	4,890	$1,790,000

2. ANNUALIZED COSTS

Item	Costs
Direct operating costs	$ 12,700
Capital charges	448,000
Solvent cost (credit)	(192,500)
Net annualized costs	$268,200

---

[a] Assumes that all solvent meets high volatility specifications.

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 11-13
U.S. Environmental Protection Agency
ESTIMATED CONTROL COSTS FOR OPEN TOP VAPOR DEGREASERS FOR THE STATE OF MICHIGAN

1. CAPITAL COSTS

Item	Costs
Safety switches	$ 10,200
Powered covers	2,432,000
Manual covers	42,400
Total	$2,484,000

2. ANNUALIZED COSTS

Item	Costs
Direct operating costs	$ 32,000
Capital charges	621,000
Solvent cost (credit)	(353,000)
Net annualized costs	$ 300,000

EXHIBIT 11-14

U.S. Environmental Protection Agency

ESTIMATED CONTROL COSTS FOR CONVEYORIZED DEGREASERS FOR THE STATE OF MICHIGAN

1. CAPITAL COSTS

Item	Costs
Refrigerator chillers	
Monorail degreasers	$ 581,400
Crossrod degreasers	768,400
Safety switches	9,500
Drying tunnel	47,500
Reduce openings	171,000
Downtime covers	51,300
Total	$1,629,100

2. ANNUALIZED COSTS

Item	Costs
Direct operating costs	$ 320,000
Capital charges	407,300
Solvent cost (credit)	(615,600)
Net annualized costs:	$ 111,700

EXHIBIT 11-15
U.S. Environmental Protection Agency
ESTIMATED NUMBER OF COLD CLEANERS
NEEDING CONTROLS IN THE STATE
OF MICHIGAN

Type of Control	Percent of Cleaners Needing Control	Number of Cleaners Needing Control
Manual covers	30	4,920

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 11-16
U.S. Environmental Protection Agency
ESTIMATED NUMBER OF OPEN TOP VAPOR DEGREASERS NEEDING CONTROL IN THE STATE OF MICHIGAN

Type of Control	Percent of Cleaners Needing Control	Number of Cleaners Needing Control
Manual covers	30	152
Safety switches	20	102
Powered cover	60	304

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 11-17
U.S. Environmental Protection Agency
ESTIMATED NUMBER OF CONVEYORIZED
DEGREASERS NEEDING CONTROLS
IN THE STATE OF MICHIGAN

Type of Control	Percent of Cleaners Needing Control	Number of Cleaners Needing Control
Refrigerated chillers for monorail and miscellaneous type cleaners[a]	36	68
Refrigerated chillers for crossrod type cleaners	54	103
Safety switches	20	38
Drying tunnel	10	19
Minimized openings	90	171
Downtime covers	90	171

---

a. Refrigerated chillers were estimated to be needed only on about 90 percent of all conveyorized vapor degreasers; thus, the percent of units needed by monorail-miscellaneous and crossrod types add only to 90 percent.

Source: Booz, Allen & Hamilton Inc.

11.5 DIRECT ECONOMIC IMPLICATIONS

11.5.1 Time Required to Implement Proposed RACT Regulations

Because so many degreasers are affected under the proposed regulation (506 open top vapor degreasers, 190 conveyorized degreasers and 16,200 cold cleaners in Michigan alone) and because each requires retrofitting of a control device, some users may not be able to comply within proposed compliance schedules because of equipment availability. Discussions with personnel from the major manufacturers of vapor and cold degreasers reveal that none are prepared to provide the necessary controls in quantities to meet a cumulative U.S.-wide demand. Some cleaners could be converted to 1,1,1-trichloroethane and thus become exempt. In fact, many metal solvent cleaners have been converted to trichloroethane in the last few years in anticipation of RACT regulations. However, not all existing machines can be converted because of inadequate condensing sections or improper materials of construction. Trichloroethane can be extremely corrosive if stabilizers are insufficiently replenished. In fact, stainless steel vapor degreasers using 1,1,1-trichloroethane have been reported to fail because of corrosion following the loss of stabilizer.

11.5.2 Effect of Compliance upon Selected Economic Indicators

Implementation of the proposed regulations are expected to have a negligible effect on factors such as value of shipments, prices, capital investment or the state economy as a whole, because of the low total capital and annualized costs required by solvent metal cleaner owners. For example, total shipments in SIC groups 25 and 33-39 alone exceeded $48.6 billion in 1975 and are expected to exceed $50 billion in 1978. Total capital expenditures for retrofitting are estimated to amount to less than 0.01 percent of this; annualized costs are estimated to be less than 0.004 percent, including a slight drop in productivity because of work practice modifications.

Similarly, implementation is expected to have a negligible impact on total capital expenditures, which amounted to about $1.5 billion in 1975. Since it appears that compliance may require several years in practice, average capital expenditures will be about $1.1 million to $1.4 million per year and would be about 0.1 percent or less of normal capital expenditures for plants in these SIC groups.[2] Considering that these expenditures are spread over service industries, and other industries also not included in SICs 25 and 33-39, the overall economic impact is even less significant.

---

1. Based on comments by several degreasing equipment manufacturers who have not geared up production for potential demands created by implementation of RACT guidelines.

2. 1976 Census of Manufactures data for average capital expenditures per employee in these SIC groups was used in conjunction with County Business Pattern data to estimate those values.

Implementation of the regulations will reduce demand for metal cleaning solvents. At an average price of 15 cents per pound (mineral spirits are about 10 cents per pound; chlorinated solvents are about 20 cents per pound) this would result in a reduction in solvent sales of about $3.0 million annually based on a reduction in emissions of about 10,000 tons yearly. This may result in a loss of employment for firms supplying metal cleaning solvents.

11.5.3 Effect of Compliance upon Energy Consumption

Carbon adsorbers, refrigerated chillers and distillation units are the principal energy consuming control devices used for controlling degreasing emissions. The refrigerated chiller, which would probably be the preferred method of control because of its low capital and operating costs, will increase a degreaser's energy consumption by about 5 percent. The EPA has estimated consumption of 0.2 kw to 2.2 kw by a chiller, used on a typical open top vapor degreaser of $1.7m^2$ size.[1] For a typical conveyorized degreaser of about $3.8m^2$ size, consumption is estimated, on this basis, to be 0.5 kw to 5.0 kw. Only conveyorized degreasers are expected to use chillers to comply; and about 90 percent or 170 of these currently do not have chillers. Assuming 2,250 hours per year operation, total additional energy consumption annually would be about 190,000 kw-hours to 1,900,000 kw-hours. This is equal to $7,600 to $76,000 per year in additional power costs, at a cost of $0.04 per kw-hour. Most of this cost is recovered by savings in solvent use.

---

[1] EPA-450/2-7-022, op.cit.

11.6 SELECTED SECONDARY ECONOMIC IMPACTS

Implementation is also expected to have minor, if not negligible, impact upon other factors, such as employment, market structure and productivity. The proposed regulations include some change in work practices which will decrease productivity in the metal cleaning operation by 5 percent to 10 percent. Since metal cleaning is normally a minor step in the manufacturing or service process, any change in productivity and employment in user plants will be insignificant.

There will, however, be some temporary increase in employment by those firms manufacturing such components as refrigeration chillers and drying tunnels, that may be required for retrofit controls. No estimates have been made because manufacturers of such components are located throughout the country. One major degreaser manufacturer, the Baron-Blakesly Company in Cicero, Illinois, could make a sizeable increase in production staff to meet the demand for components. This temporary increase however, may be balanced by a slight decrease in employment occurring because of lower solvent consumption. The decrease would occur primarily in shipping and repackaging operations.

The implementation of the RACT guidelines should not have any major effect on the current market structure of the industries using solvent metal cleaning. Cleaners requiring highest retrofitting costs (i.e., for conveyorized cleaners) are generally owned by large firms. Smaller firms would be expected to have only cold cleaners or open top vapor degreasers. The highest capital costs would be for an open top unit which would require an expenditure of $8,000 or less to comply. This is not expected to be a significant financial burden even to small-sized firms.

* * * *

Exhibit 11-18, on the following page, summarizes the conclusions presented in this report.

EXHIBIT 11-18

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	15,000-20,000 plants
Indication of relative importance of industrial section to state economy	Value of shipments of firms in SIC groups affected is in the range of $58 billion, about two-thirds of the state's 1977 value of shipments.
Current industry technology trends	Where technically feasible, firms are substituting exempt solvents
1977 VOC emissions (actual)	42,500 Tons/year of which 17,500 tons are subject to RACT
Industry preferred method of VOC control to meet RACT guidelines	Substitution. Otherwise lowest cost option as specified by EPA will be used.
Assumed method of VOC control meet RACT guidelines	Equipment modifications as specified by the RACT guidelines

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$5.9 million
Annualized operating cost (statewide)	$0.7 million, (approximately 0.0012 percent of the 1977 statewide value of shipments)
Price	Metal cleaning is only a fraction of manufacturing costs; price affect expected to be less than 0.0012 percent
Energy	Less than a 1000 equivalent barrels of oil per year in reduction
Productivity	5-10 percent decrease for manually operated degreasers. Will propably not affect conveyorized cleaners.
Employment	No effect except a possible slight decrease in firms supplying metal degreasing solvents
Market Structure	No change
RACT timing requirements (1982)	Equipment availability--only a few companies now supply the recommended control modifications
Problem Areas	No significant problem areas seen. Most firms will be able to absorb cost.
VOC emission after RACT control	32,500 tons/year (76 percent of 1977 VOC emission level--however, this does not include emission controls for exempt solvents)
Cost effectiveness of RACT control	$70 annualized cost per ton of emissions reduced

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

U.S. Department of Commerce, County Business Patterns, 1976.

U.S. Department of Commerce, Census of Manufactures, 1972.

U.S. Environmental Protection Agency, Control of Volatile Organic Emissions from Solvent Metal Cleaning EPA-450/2-77-022, November 1977.

U.S. Environmental Protection Agency, Regulatory Guidance for Control of Volatile Organic Emissions from 15 Categories of Stationary Sources EPA-905/2-78-001, April 1978.

Dow Chemical Company, Study to Support New Source Performance Standards for Solvent Metal Cleaning Operations EPA Contract 68-02-1329, June 30, 1976.

Private conversations with the following:

Detrex Chemical Company, Detroit, Michigan

Ethyl Corporation, Baton Rouge, Louisiana

DuPont, Wilmington, Delaware

Dow Chemical Company, Midland, Michigan

PPG, Pittsburgh, Pennsylvania

Allied Chemical Company, Morristown, New Jersey

R. R. Street, Detroit, Michigan

Baron-Blakeslee Corporation, Cicero, Illinois

Hercules Inc., Wilmington, Delaware

Texas Eastman, Longview, Texas

14.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR BULK GASOLINE PLANTS IN THE STATE OF MICHIGAN

14.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR BULK GASOLINE PLANTS IN THE STATE OF MICHIGAN

This chapter presents a detailed analysis of the impact of implementing RACT controls for bulk gasoline plants in the State of Michigan. The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation of the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic implications
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of bulk gasoline plants, interviews, and analysis.

14.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methdology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for bulk gasoline plants in the State of Michigan.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

14.1.1 Industry Statistics

Industry statistics on bulk gasoline plants were obtained from several sources. All data were converted to a base year, 1977, based on specific scaling factors:

- The number of establishments for 1977 was obtained from the Michigan Petroleum Association Directory.
- The number of employees in 1977 was derived from the 1972 Census of Wholesale Trade, Petroleum Bulk Stations and Terminals, by determining the number of employees per establishment in 1972 and multiplying this factor by the number of establishments reported for 1977.
- The number of gallons of gasoline sold in 1977 in the State of Michigan was estimated based on 1972 data reported in the 1972 Census of Wholesale Trade, Petroleum Bulk Stations and Terminals and factored to 1977 based on the net national change in demand for gasoline from 1972 to 1977 (10 percent growth), which was reported in the National Petroleum News Fact Book, 1978.
- Sales, in dollars, of motor gasoline for 1977 were estimated by multiplying the number of gallons of gasoline sold in 1977 by the national dealer tankwagon price in 1977 (42.51¢/gallon—reported in the National Petroleum News Fact Book, 1978).

14.1.2 VOC Emissions

VOC emissions from bulk gasoline plants in Michigan were calculated by multiplying the estimated annual throughput of gasoline by emission factors reported in Hydrocarbon Control Strategies for Gasoline Marketing Operations, EPA-450/3-78-017.

The Michigan Department of Natural Resources, Air Quality Division conducted a survey of bulk gasoline plants in Michigan and estimates that about 50 percent of the bulk gasoline plants employ top submerged filling and the remaining 50 percent employ top splash filling. These findings were used in estimating emissions.

14.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions for bulk gasoline plants are described in Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035. These data provide the alternatives available for controlling VOC emissions from bulk gasoline plants. Several studies of VOC emission control were also analyzed in detail, and interviews with petroleum trade associations, bulk plant operators, and vapor control equipment manufacturers were conducted to ascertain the most likely types of control processes which would be used in bulk gasoline plants in Michigan. The specific studies analyzed were: Evaluation of Top Loading Vapor Balance Systems for Small Bulk Plants, EPA 340/1-77-014; Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013; Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources, EPA PB-236 921; and Study of Gasoline Vapor Emission Controls at Small Bulk Plants, EPA PB-267-096.

The alternative types of vapor control equipment likely to be applied to bulk gasoline stations were arrayed, and percentage reductions from using each type of control were determined. The methodology for the cost analysis based on this scheme is described in the following paragraphs.

14.1.4 Cost of Vapor Control Systems

The costs of vapor control systems were developed by:

- Determining the alternative types of control systems likely to be used

- Estimating the probable use of each type of control system

- Defining systems components

- Developing installed capital costs for systems components

- Aggregating installed capital costs for systems components

- Defining two model plants

- Developing costs of control systems for model plants including

    - Installed capital cost
    - Direct operating costs
    - Annual capital charges
    - Gasoline credit
    - Net annual cost

- Assigning model plant costs to plants in Michigan

- Aggregating costs to the total industry in Michigan.

Costs were determined from analyses of the following previous studies:

- Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA 450/2-77-035

- Study of Gasoline Vapor Emission Controls at Small Bulk Plants, EPA PB-267-096

- Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013

- Evaluation of Top Loading Vapor Balance Systems for Small Bulk Plants, EPA 340/1-77-014

and from interviews with petroleum marketers' associations, bulk plant operators, and vapor control equipment manufacturers.

A profile of bulk plants for the United States was used to characterize bulk gasoline plants in Michigan since detailed data on bulk gasoline plant throughput were not available for Michigan.

14.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements needed to implement RACT; assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability; comparing the direct costs of RACT control to various state economic indicators; and assessing the secondary effects on market structure, employment, and productivity as a result of implementing RACT controls in Michigan.

14.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost, and economic impact of implementing RACT controls on bulk gasoline plants in Michigan. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies, and best engineering judgment. Exhibit 14-1, on the following page, rates each study output listed and the overall quality of the data.

Exhibit 14-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics	●		
Emissions		●	
Cost of emissions control		●	
Statewide costs of emissions			●
Economic Impact		●	
Overall quality of data		●	

Source: Booz, Allen & Hamilton, Inc.

14.2 INDUSTRY STATISTICS

Industry characterisitcs, statistics, and business trends for bulk gasoline plants in Michigan are presented in this section. The discussion includes a description of the number of facilities and their characteristics, a comparison of the size of the bulk gasoline plant industry to state economic indicators, a historical characterization and description of the industry, and an assessment of future industry patterns. Data in this section form the basis for assessing the impact on this industry of implementing RACT to VOC emissions from bulk gasoline plants in Michigan.

14.2.1 Size of the Industry

There were an estimated 808 bulk gasoline plants, as of 1977, in Michigan. Industry sales were in the range of $519 million, with an estimated yearly throughput of 1.222 billion gallons of gasoline. The estimated number of employees in 1977 was 4,549. These data and the sources of information are summarized in Exhibit 14-2, on the following page. Annual capital investments have not been estimated. In general, bulk plant capital investments are for plant and equipment to replace worn-out facilities, modernize the establishments, or improve operating efficiencies.

14.2.2 Comparison of the Industry to the State Economy

A comparison of the bulk gasoline plant industry to the economy of the State of Michigan is shown in this section by comparing industry statistics to state economic indicators. Employees in the bulk gasoline plant industry represent 0.1 percent of the total state civilian labor force of Michigan. The value of gasoline sold from bulk plants represented less than one percent of the total value of wholesale trade in Michigan in 1977.

14.2.3 Characterization of the Industry

Bulk plants are an intermediate distribution point in the petroleum product marketing network as shown in Exhibit 14-3, following Exhibit 14-2. Bulk gasoline plants compete with bulk gasoline tank terminals and large retail gasoline outlets. Ownership and operation of bulk plants are predominantly by independent jobbers and commissioned

Exhibit 14-2

U.S. Environmental Protection Agency

INDUSTRY STATISTICS FOR BULK GASOLINE PLANTS IN MICHIGAN

Number of Establishments	Number of Employees	Sales ($ Billion, 1977)	Gasoline Sold (Billions of Gallons)
808[(a)]	4,549[(b)]	0.519[(c)]	1.22[(d)]

(a) Michigan Petroleum Association

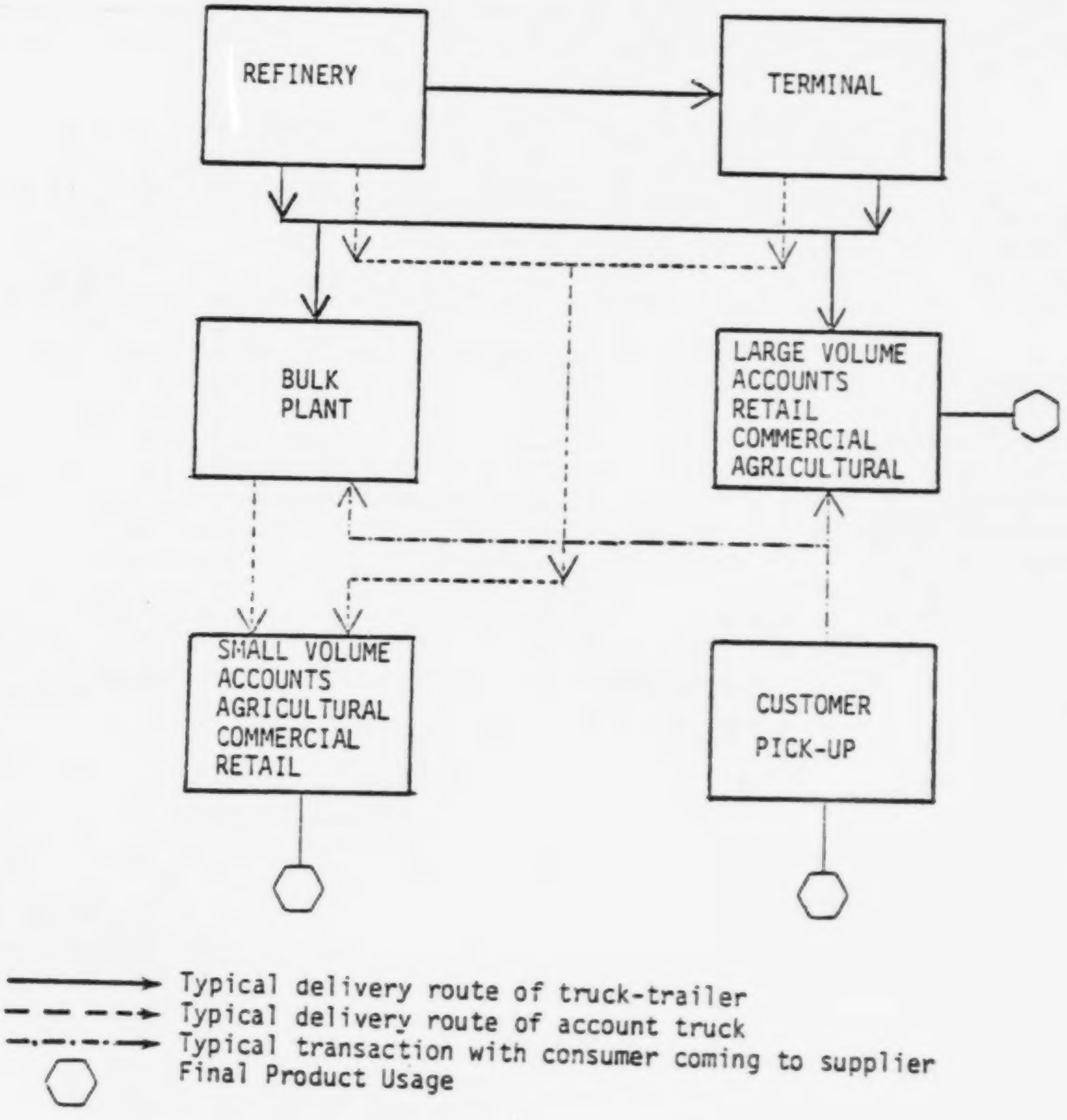
(b) Booz, Allen & Hamilton estimate based on the ratio of the number of employees to the number of establishments in 1972

(c) Number of gallons of motor gasoline sold in 1977 multiplied by the national dealer tankwagon price in 1977 (42.51¢/gallon). National Petroleum News Fact Book, 1978

(d) Booz, Allen & Hamilton estimate based on national change in demand for gasoline from 1972 to 1977 (+10%). National Petroleum News Fact Book, 1978.

Exhibit 14-3

U.S. Environmental Protection Agency
GASOLINE DISTRIBUTION NETWORK


REFINERY
TERMINAL
BULK PLANT
LARGE VOLUME ACCOUNTS RETAIL COMMERCIAL AGRICULTURAL
SMALL VOLUME ACCOUNTS AGRICULTURAL COMMERCIAL RETAIL
CUSTOMER PICK-UP
Typical delivery route of truck-trailer
Typical delivery route of account truck
Typical transaction with consumer coming to supplier
Final Product Usage

Source: Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013, September 1976, p. 3-2.

agents but also includes cooperatives and salaried employees. The independent jobber owns the equipment and structures at his bulk plant, the inventory, and rolling stock, and he contracts directly with the oil company for gasoline. A commissioned agent usually does not own the equipment and facilities but operates the bulk plant for a major integrated oil company.

Bulk gasoline plants are typically located near towns and small cities, since their predominant market is agricultural and small retail accounts. The maximum daily throughput of a bulk gasoline plant ranges from less than 2,000 gallons per day up to 20,000 gallons per day. Exhibit 14-4, on the following page, shows a typical distribution of bulk gasoline plants by plant throughput in Michigan.

It is estimated that the majority of the bulk gasoline plants are up to 25 years old, with a few new modernized, higher volume plants. Forty years ago, bulk gasoline plants were a major link in the gasoline distribution network. From that time, their importance has been declining in the marketing sector of the petroleum industry, basically for economic reasons. There is evidence that profitability in bulk gasoline plants has been decreasing. The number of bulk gasoline plants decreased by 11 percent nationally from 1967 to 1972 and is predicted to continue declining in the near term.[1] This decline is largely attributable to major oil companies disposing of commission-agent-operated bulk plants.

---

[1] National Petroleum News Fact Book, 1976.

Exhibit 14-4

U.S. Environmental Protection Agency DISTRIBUTION OF BULK GASOLINE PLANTS BY AMOUNT OF THROUGHPUT

Gasoline Throughput (gallons per day)	Percentage of Plants
Less than 2,000	24
2,000 to 3,999	27
4,000 to 5,999	16
6,000 to 7,999	8
8,000 to 9,999	12
10,000 to 11,999	4
12,000 to 13,999	1
14,000 to 15,999	2
16,000 to 17,999	1
18,000 to 20,000	5

Source: Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013, September 1976.

14.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on bulk gasoline plant operation, estimated VOC emissions from bulk gasoline plant operations in Michigan, the extent of current control in use, the requirements of vapor control required by RACT and the likely RACT alternatives which may be used for controlling VOC emissions from bulk gasoline plants in Michigan.

14.3.1 Bulk Gasoline Plant Operations

Bulk gasoline plants are typically secondary distribution facilities which receive gasoline from bulk gasoline tank terminals by trailer-transport trucks; store it in above-ground storage tanks; and subsequently dispense it via account trucks to local farms, businesses and service stations. Bulk gasoline plants with an average daily gasoline throughput of 20,000 gallons per day or less have been defined by EPA as requiring vapor control equipment to reduce VOC emissions from bulk gasoline plant operations.

14.3.1.1 Facilities

Bulk plant facilities generally include tanks for gasoline storage, loading racks and incoming and outgoing tank trucks.

The most prevalent type of gasoline storage tank found at bulk gasoline plants is the above-ground storage tank. These tanks are usually cylindrical with domed ends (vertical or horizontal). Typical storage capacities range from 13,000 to 20,000 gallons and the number of tanks at each plant ranges from one to eight, with an average of three tanks per plant.

A typical loading rack used for dispensing gasoline to account trucks includes shut-off valves, meters, relief valves, electrical grounding, lighting, by-pass plumbing and loading arms. Loading may be by bottom fill, top splash, submerge fill pipe through hatches, or dry connections on the tops of trucks. Top submerged filling is used in about 50 percent of bulk plants and top splash filling in the remaining 50 percent. A typical bulk gasoline plant has one loading rack with an average gasoline pumping rate of 125 gallons per minute.

Trailer-transport trucks supply bulk plants with gasoline, while account trucks deliver gasoline to bulk plant customers. Trailer-transport trucks have four to six compartments and deliver approximately 8,000 gallons of gasoline to the bulk plant. Most commonly, trailer-transport trucks are owned by oil companies or commercial carriers. Account trucks usually have four compartments with a total capacity of 2,000 gallons. Bulk plants have an average of two account trucks, and these trucks are most commonly owned by the bulk plant operator.

14.3.1.2 Operations

VOC emissions occur at various stages in bulk plant operations. Gasoline is unloaded from trailer-transport trucks into gasoline storage tanks. The primary method of unloading gasoline into storage tanks is to submerge fill. Emissions occur from this operation through the displacement of vapor laden air in the storage tank with gasoline. Vapor balancing between the tank truck and the storage tank is the recommended method for controlling these emissions.

Another major source of emissions is from vaporization of gasoline in the storage tank because of changes in pressure in the tank caused by variation in temperature. These emissions, referred to as breathing losses, are controlled by adjusting the pressure relief valve on the storage tank.

The final major occurrence of emissions is during loading of account trucks which dispense gasoline to bulk plant customers. The cause of emissions during account truck filling is from turbulence of the liquids being loaded and the resulting vaporization. The vapor laden air in the account truck is displaced to the atmosphere during filling. Top loading account trucks cause greater emissions than trucks loading from the bottom since greater liquid turbulence occurs. Submerged filling or bottom filling and vapor balancing the account truck and the storage tank are the primary methods for controlling emissions.

14.3.2 Emissions and Current Controls

This section presents the estimated VOC emissions from bulk gasoline plants in Michigan in 1977 and the current level of emission control already implemented in the state. Exhibit 14-5, on the following page, shows the total estimated

Exhibit 14-5

U.S. Environmental Protection Agency
VOC EMISSIONS FROM BULK GASOLINE PLANTS IN MICHIGAN

Number of Facilities	Estimated Number of Tanks	Average Daily Throughput (gallons)	Total Emissions (tons/year)
808	2,424	3,347,000	15,411

Source: Booz, Allen & Hamilton estimate.

emissions in tons per year from bulk plants in Michigan. The estimated 1977 VOC actual emissions from the 808 bulk plants are 15,411 tons per year.

It was reported that 50 percent of the bulk gasoline plants in Michigan employ top submerge filling and the remainder use top splash filling.

14.3.3 RACT Guidelines

The RACT guidelines for VOC emission control from bulk gasoline plants require the following control systems:

- Top submerged or bottom fill of gasoline storage tanks and outgoing account trucks
- Vapor balancing between the incoming trailer-transport truck and the gasoline storage tank
- Vapor balancing between the gasoline storage tank and the outgoing account truck
- Proper operation and maintenance of equipment.

Exhibit 14-6, on the following page, summarizes the RACT guidelines for VOC emissions control from bulk gasoline plants.

14.3.4 Selection of the Most Likely RACT Alternatives

Control of VOC emission from bulk gasoline plants is achieved using submerged or bottom filling of storage tanks and account trucks and vapor balancing between the loading and unloading of incoming and outgoing trailer-transport trucks and the gasoline storage tanks. There are several alternative means of achieving vapor control at bulk gasoline plants, based on the manner in which the bulk plant is operated.

EXHIBIT 14-6
U.S. Environmental Protection Agency
VOC EMISSION CONTROL TECHNOLOGY FOR
BULK GASOLINE PLANTS

Facilities Affected	Sources of Emissions	RACT Control Guideline
Bulk plants with daily throughputs of 76,000 liters (20,000 gallons) of gasoline or less	Vapor displacement from filling account trucks, and breathing losses and working losses from storage tanks	Submerge filling and vapor balancing: . Vapor balancing of transport truck and storage tank . Vapor balancing of storage and account truck
	Cracks in seals and connections	Proper operation maintenance
	Improper hook up of liquid lines and top loading nozzles	Proper operation maintenance
	Truck cleaning	Proper operation maintenance
	Pressure vacuum relief valves	Proper operation maintenance

Source: *Control of Volatile Organic Emissions from Bulk Gasoline Plants*, EPA-450/2-77-035.

Three likely control alternatives, summarized in Exhibit 14-7, on the following page, are discussed separately in the paragraphs which follows.

14.3.4.1 Alternative I

Control Alternative I involves top submerged loading and equipping the bulk plant with a vapor balancing system. In detail, this control alternative implies:

- Submerged filling of gasoline storage tanks
- Vapor balancing between the incoming trailer-transport truck and the gasoline storage tank
- Submerged top loading of outgoing account trucks
- Vapor balancing of gasoline storage tank and outgoing account truck
- Equipping account trucks with vapor balancing connections.

It is estimated that bulk plants in Michigan would select Control Alternative I to achieve vapor recovery to meet the state RACT requirements. During interviews, the industry has questioned whether vapor recovery by this control method will achieve 90 percent emissions recovery as stated in the RACT guidelines.

14.3.4.2 Alternative II

Control Alternative II involves implementing a complete vapor balancing system on bulk plants which currently operate with bottom filling. In detail this control alternative encompasses:

- Vapor balancing between the incoming trailer-transport truck and the gasoline storage tank
- Vapor balancing between the gasoline storage tank and the outgoing account truck

Exhibit 14-7

U.S. Environmental Protection Agency
ALTERNATIVE CONTROL METHOD
FOR VAPOR CONTROL AT BULK GASOLINE PLAN

Alternative Number	Description of Control Method
I	Top submerged filling and vapor balance entire system
II	Vapor balance existing bottom filled bulk plant
III	Convert top filled bulk plant to bottom filled, and vapor balance total system

Source: Booz, Allen & Hamilton Inc. analysis of Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035.

- Modification of account trucks to accommodate a vapor recovery connection.

The cost for this alternative would be similar to costs for Control Alternative I.

14.3.4.3 Alternative III

Control Alternative III involves converting top loading bulk gasoline plants to bottom filling and implementing a complete vapor balancing system. In detail, this control alternative entails:

- Converting the loading rack to bottom filling
- Converting storage tank loading to bottom filling
- Vapor balancing the incoming trailer-transport truck and the gasoline storage tank
- Converting the account truck to bottom loading and installing vapor balancing connections on the account truck.

The additional cost of converting a bulk plant from top filling to bottom filling makes Control Alternative III more costly than Control Alternative I. This additional cost may be attributable to improved bulk plant operations, rather than compliance with the proposed limitations.

14.4 COST AND HYDROCARBON REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Costs for VOC emission control equipment are presented in this section. The costs for the three alternative control systems described in Section 14.3 are described individually, followed by costs for typical bulk plants. The final section then presents a projection of typical bulk gasoline plant control costs to the statewide industry.

14.4.1 Costs for Alternative Control Systems

The costs for the three alternative control systems (summarized in Exhibit 14-8, on the following page) were derived from analysis of the RACT guidelines, from interviews with bulk plant operators and petroleum marketing trade associations and from previous cost and economic studies of small bulk plants.

Control Alternative I is expected to be the most likely applied system for bulk plants in Michigan. The U.S. EPA currently endorses the cost estimates developed by Pacific Environmental Services, Inc. for the Houston/Galveston area bulk plants. However, several large volume bulk plant operators who were interviewed have reported vapor control costs in excess of $50,000 which included conversion of the loading rack to bottom filling.

Control Alternative II is similar in cost to Control Alternative I.

Control Alternative III is the most costly control system. Several bulk gasoline plant operators interviewed in California and Maryland have adopted this system, although it cannot be shown from the data in Michigan that any bulk gasoline plant in Michigan would be willing to implement a system this costly. This alternative, therefore, is not included in the projection of vapor control costs to the statewide industry in the next section.

14.4.2 Costs for Two Model Bulk Plants

Two model bulk plants and their associated vapor control costs are characterized in this section. The costs are

Exhibit 14-8
U.S. Environmental Protection Agency
COSTS OF ALTERNATIVE VAPOR CONTROL SYSTEMS

Cost Estimate	Alternative I	Alternative II	Alternative III (Includes conversion to botton filling)
National Oil Jobbers Council estimate	1 truck (4-compartments) 1 loading rack (3 arms) 3-inch system Pre-set meters Direct Cost (no labor) $20,524 (without air) $22,754 (with air)	Similar to costs for alternative I	1 truck (4-compartments) 1 loading rack (3 arms) 3-inch system Pre-set meters Direct cost (No labor) $27,729
Pacific Environmental Services estimate of Houston/Galveston area system	1 loading rack Meters Average installed cost $3,200 (without metering) $7,700 (with metering)		
Wiggins system			1 truck 4-compartments) 1 loading rack (4 arms) Pre-set meters Installed cost $17,352-$18,416

Source: National Oil Jobbers Council, Pacific Environmental Services and Wiggins, Connectors Division, Delaval Turbine, Inc.

based on the control estimates for Control Alternative I reported by Pacific Environmental Services, Inc. for bulk plants in the Houston/Galveston area. Several other bulk plant operators have reported costs in excess of $50,000 for vapor control systems although U.S. EPA estimates that these systems exceed the level of adequacy required to meet RACT.

Exhibit 14-9, on the following page, defines two model bulk plant characteristics and associated control costs. It is assumed that approximately 75 percent of the bulk plants in Michigan can be characterized by Model Plant A; the remaining 25 percent are assumed to be characterized by Model Plant B.

The costs for the model plants are used in section 14.4.3 to project costs of vapor control equipment to the industry statewide. The costs for each model plant are:

- Installed capital cost, which includes parts and labor
- Annualized direct operating costs, expected to be 3 percent of installed capital costs, including costs for labor, utilities, recordkeeping and training costs.[1]
- Annualized capital charges, estimated to be 25 percent of installed capital costs, including costs for depreciation, interest, maintenance, taxes, and insurance
- Net annualized costs, which are the sum of the capital charges and direct operating costs. It should be noted that gasoline credit has not yet been accounted for. Gasoline credit will be taken into account when the costs are extrapolated to the industry.

Another cost characterization that can be made is hydrocarbon reduction versus cost. This finding will also be shown in the statewide analysis.

---

[1] Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035.

Exhibit 14-9

U.S. Environmental Protection Agency
DESCRIPTION AND COST OF MODEL BULK PLANTS EQUIPPED WITH VAPOR CONTROL SYSTEMS

Bulk Plant Characteristics	Model Bulk Plant A	Model Bulk Plant B
Throughput	2,500 gallons/day	13,000 gallons/day
Loading racks	1	1
Storage tanks	3	3
Account trucks	2	4
Compartment per account truck	4	4
Vapor control system	Alternative I	Alternative I
Bulk Plant Costs		
Installed capital cost[a]	$13,700	$19,700
Annualized direct operating costs @ 3 percent of installed cost	411	591
Annualized capital charges @ 25 percent of installed capital cost	3,425	4,925
Net annualized cost (not including gasoline credit)	3,836	5,516

---

[a] Assume $3,000 installed capital cost to modify one four compartment account truck.

Source: Booz, Allen & Hamilton Inc.

14.4.3 Projection to the Statewide Industry

Exhibit 14-10, on the following page, shows the projection of vapor recovery costs to the statewide industry in Michigan. The estimates are based on the following:

- In Michigan, 75 percent of the bulk gasoline plants can be characterized by Model Plant A and the remaining can be characterized by Model Plant B.
- All bulk plants will implement the Control Alternative I vapor control system to comply with RACT.

Actual costs to bulk plant operators may vary depending on the type of control alternative and manufacturer's equipment selected by each bulk plant operator.

Based on the above assumptions, the total cost to the industry for installing vapor recovery equipment is estimated to exceed $12 million. The amount of gasoline prevented from vaporizing using vapor control is valued at $149,000. Ten percent of total emissions can be credited to the bulk plant since installation of vapor control equipment will reduce the amount of vaporization by approximately 10 percent. The annual cost per ton of emissions controlled is estimated to be $289 per ton.

The statewide costs of vapor control systems by size of bulk gasoline plant are analyzed and arrayed in Exhibit 14-11, following Exhibit 14-10. It is noted that bulk plants with throughput less than 4,000 gallons per day achieve only 21-percent reduction in overall emissions yet bear over 45 percent of the annual cost of hydrocarbon emission control costs.

Exhibit 14-10

U.S. Environmental Protection Agency
STATEWIDE COSTS OF VAPOR CONTROL SYSTEMS FOR BULK GASOLINE PLANTS

Characteristic/Cost Item	Data
Number of facilities	808
Total annual throughput (billions of gallons)	1.22
Uncontrolled emissions (current) (tons/year)	15,411
Emission reduction (tons/year)	11,401
Net emissions (after control) (tons/year)	4,010
Installed capital ($ million, 1977)	12.342
Direct annual operating cost ($million, 1977)	0.370
Annual capital charges ($ million, 1977)	3.08
Annual gasoline credit[a] ($ millions, 1977)	0.149
Net annualized cost ($ million, 1977)	3.301
Annual cost per ton of emissions reduced ($ per ton)	289

---

a. Includes cost of $60,600 to equip 404 bulk gasoline plants with a submerge fill pipe at a cost of $150 per plant.

b. Based on 10 percent of reduced emissions remaining at bulk plant resulting from less turbulence in gasoline loading and valued at 40¢ per gallon.

Source: Booz, Allen & Hamilton Inc.

Exhibit 14-11

U.S. Environmental Protection Agency

STATEWIDE COSTS OF VAPOR CONTROL SYSTEM BY SIZE OF BULK GASOLINE PLANT

Bulk Plant Gasoline Throughput (gallons per day)	Percentage of Plants	Current Estimated Annual VOC Emissions (tons per year)	Estimated Annual VOC Emissions After RACT Control (tons per year)	Net VOC Emission Reduction (tons per year)	Percentage of Total VOC Emissions Reduced	Estimated Annual Cost ($ millions, 1977)	Percent of Total Annual Cost For Vapor Recovery	Net Hydrocarbon Cost Effectiveness $\left(\frac{\$, 1977}{\text{tons per year}}\right)$
Less than 2,000	24	986	257	729	6.4	.723	21.54	991
2,000 - 3,999	27	2,235	581	1,654	14.5	.812	24.19	491
4,000 - 5,999	16	2,204	573	1,631	14.3	.484	14.42	297
6,000 - 7,999	8	1,541	401	1,140	10.0	.252	7.51	221
8,000 - 9,999	12	2,974	774	2,200	19.3	.524	15.61	238
10,000 - 11,999	4	1,217	317	900	7.9	.173	5.15	192
12,000 - 13,999	1	339	88	251	2.2	.043	1.28	171
14,000 - 15,599	2	832	216	616	5.4	.086	2.56	139
16,000 - 17,999	1	463	120	343	3.0	,043	1.28	125
18,000 - 20,000	5	2,620	682	1,938	17.0	.216	6.44	111

Source: Booz, Allen & Hamilton Inc.

14.5 DIRECT ECONOMIC IMPLICATIONS

This section presents the direct economic implications of implementing RACT controls to the statewide industry, including availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost passthrough), state economic variables and capital investment.

14.5.1 RACT Timing

RACT must be implemented statewide by January 1, 1982. This implies that bulk gasoline plant operators must have vapor control equipment installed and operating within the next three years. The timing requirements of RACT impose several requirements on bulk plant operators including:

- Determining appropriate vapor control system
- Raising capital to purchase equipment
- Generating sufficient income from current operations to pay the additional annual operating costs incurred with vapor control
- Acquiring the necessary vapor control equipment
- Installing and testing vapor control equipment to insure that the system complies with RACT.

The sections which follow discuss the feasibility and the economic implications of implementing RACT within the required timeframe.

14.5.2 Feasibility Issues

Technical and economic feasibility issues of implementing RACT controls are discussed in this section.

Several bulk plants in the U.S. have attempted to implement vapor control systems with varying degrees of success. One bulk plant operator interviewed in Maryland implemented vapor control at a cost of $65,000 in 1974. The operator indicated that recent tests have shown the system operates well within the 90 percent control requirement of RACT. This particular bulk plant was converted to bottom filling and completely vapor balanced. The plant's throughput was 20,000 gallons per day and included one loading rack and three account trucks. This plant would be characterized as installing a sophisticated Alternative III control system. The plant is also operated by a major oil company, so capital availability problems were not similar to a small, independently owned bulk plant.

Bulk plants in the Houston/Galveston area, on the contrary, have implemented "bare bone" type control systems that were individually designed and installed at a bulk plant which was owned by a major oil company. No emission data are available to verify whether these systems are in compliance, but U.S. EPA estimates that these control systems are sufficient to meet the requirements of RACT. These systems are not marketed by any equipment manufacturer; therefore, their availability for widespread application is doubtful at the present time.

State adoption of RACT regulations will generate a demand for economical vapor control systems for bulk plants. It is, therefore, anticipated that off-the-shelf systems could be developed within the next four years that are similar to the control system implemented in the Houston/Galveston area; thus making the delivery of RACT control equipment feasible.

A number of economic factors are involved in determining whether a specific bulk plant operator will be able to implement vapor control systems and still remain profitable. These include:

- Degree of competition
- Ability to pass on a price increase
- The current profitability of the plant
- Age of the plant
- State of repair of the plant
- Ownership—major oil company or private individual.

By dividing the annual cost per plant by annual plant throughput it is estimated that small bulk plants, with throughput less than 4,000 gallons, could possibly experience a direct cost increase of $0.0028 to $0.005 per gallon (assuming full cost passthrough if they implement RACT). This may affect up to 50 percent of the bulk gasoline plants in the state. Many of these plants are likely to be located in rural areas.

The key to the direct economic impact will be the ability of a bulk plant operator to pass on up to a 0.5 cent increase in the price of gasoline to customers (assuming a full cost passthrough). One small bulk plant operator in Missouri reported during an interview that his gross profit margin per gallon of gasoline is 4 to 5 cents per gallon. His net profit margin is 0.5 cent per gallon. This operator stated that he plans to discontinue operations rather than comply with RACT. Again, sufficient data are not available to determine if this would be typical of small bulk plants in the state. In a previous study of the economics of vapor recovery for small bulk plants, a trend of declining profitability in bulk plant operations was identified.[1] If this trend continues, vapor control systems may not be affordable at marginal plants. Many bulk plants now operate at a profit only because their plants are fully depreciated. In the same study it was also determined that a large percentage of small bulk plants may not be able to raise sufficient capital to purchase vapor control equipment. Furthermore, it is estimated that the price of vapor control systems is likely to increase in the future at a rate greater than the GNP. One bulk plant operator stated that prices for vapor control have risen 30 percent over the past three years. It is possible that the industry decline could continue and that some bulk plant operators may cease operations because of their present financial condition and the additional financial burden of the RACT requirements.

The paragraphs which follow compare statewide compliance costs of RACT control, in 1977 dollars, to various economic indicators.

14.5.3 Comparison of Direct Cost With Selected Direct Economic Indicators

This section presents a comparison of the net increase in the annual operating cost of implementing RACT with the total value of gasoline sold in the state, the value of wholesale trade in the state, and the unit price of gasoline.

The net increase in the annualized cost to the bulk gasoline plants due to RACT represents 0.6 percent of the total gasoline sold in the state. When compared to the statewide value of wholesale trade, these annual cost increases are minimal. The impact on the unit price of gasoline varies with the bulk plant throughput. As discussed in the preceding section, the small bulk plants may experience a direct cost increase of up to 0.5 cent per gallon of gasoline sold, whereas the large bulk plants may experience a much smaller direct cost increase. Assuming a full cost passthrough, the price of gasoline is likely to rise more in rural areas than urban areas (i.e., the small volume bulk plants tend to be located in rural areas).

---

[1] Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013, September 1976.

14.6 SELECTED SECONDARY ECONOMIC IMPACTS

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

For bulk gasoline plants that comply with the RACT requirements, no additional manpower requirements are expected. Overall bulk gasoline plant industrial sector employment may continue if the number of bulk gasoline plants operating in the state declines. Based on the statewide estimates of number of employees and number of bulk plants, an average of approximately 4.6 jobs may be lost with the closing of a bulk plant. No estimate was made of the number of bulk plants that may close due to RACT.

The impact on the market structure for bulk plants differs significantly in urban and rural areas. The importance of bulk plants in the urban areas may be declining because of competition from retailers and tank truck terminals and could continue to decline regardless of RACT requirements.

In rural areas, the bulk plants serve as a vital link in the gasoline distribution network, since large trailer transport trucks cannot be accommodated by many rural roads serving the farm accounts. It is estimated that approximately 60 percent of the customers served by the small bulk plants in the rural areas are farm accounts, which could be severely impacted if many small bulk plants are forced out of business. The increased annualized cost of complying with RACT may create market imbalances if the compliance cost cannot be passed on to the marketplace in terms of a price increase (i.e., the market structure would tend to concentrate further). As small bulk plant operators cease operation, the supply of fuel to some farmers may be threatened. Bulk plants not equipped with vapor control equipment may not be able to serve gasoline service stations equipped with vapor control equipment due to incompatible hardware configurations. A uniform policy, therefore, is necessary so that market disruptions due to equipment incompatibility are minimized.

The productivity of a specific bulk plant will be a function of the type of vapor control system installed. If a bulk plant converts to bottom filling along with vapor recovery, the productivity of the bulk plant should increase.

14.6 SELECTED SECONDARY ECONOMIC IMPACTS

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

For bulk gasoline plants that comply with the RACT requirements, no additional manpower requirements are expected. Overall bulk gasoline plant industrial sector employment may continue if the number of bulk gasoline plants operating in the state declines. Based on the statewide estimates of number of employees and number of bulk plants, an average of approximately 4.6 jobs may be lost with the closing of a bulk plant. No estimate was made of the number of bulk plants that may close due to RACT.

The impact on the market structure for bulk plants differs significantly in urban and rural areas. The importance of bulk plants in the urban areas may be declining because of competition from retailers and tank truck terminals and could continue to decline regardless of RACT requirements.

In rural areas, the bulk plants serve as a vital link in the gasoline distribution network, since large trailer transport trucks cannot be accommodated by many rural roads serving the farm accounts. It is estimated that approximately 60 percent of the customers served by the small bulk plants in the rural areas are farm accounts, which could be severely impacted if many small bulk plants are forced out of business. The increased annualized cost of complying with RACT may create market imbalances if the compliance cost cannot be passed on to the marketplace in terms of a price increase (i.e., the market structure would tend to concentrate further). As small bulk plant operators cease operation, the supply of fuel to some farmers may be threatened. Bulk plants not equipped with vapor control equipment may not be able to serve gasoline service stations equipped with vapor control equipment due to incompatible hardware configurations. A uniform policy, therefore, is necessary so that market disruptions due to equipment incompatibility are minimized.

The productivity of a specific bulk plant will be a function of the type of vapor control system installed. If a bulk plant converts to bottom filling along with vapor recovery, the productivity of the bulk plant should increase.

However, some vapor control systems may decrease plant productivity if flow rates substantially decline, requiring longer times to load and unload trucks.

* * * *

Exhibit 14-12, on the following page, presents a summary of the findings of this report.

Exhibit 14-12

U.S. Environmetnal Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR BULK GASOLINE PLANTS IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	800
Indication of relative importance of industrial section to state economy	1977 industry sales were $520 million. The estimated annual throughput was 1.22 billion gallons. Primary market is rural accounts
Current industry technology trends	Only small percent of industry has new/modernized plants
1977 VOC actual emissions	15,400 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Top submerged or bottom fill and vapor balancing (cost analysis reflects top submerged fill, not bottom fill)

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$12.40 million
Annualized cost (statewide)	$3.3 million (approximately 0.6 percent of value of shipments)
Price	Assuming a "direct cost pass-through" · Industry-wide—$0.0025 per gallon increase · Small operations--$0.0025 to $0.005 per gallon increase
Energy	Assuming full recovery of gasoline—net savings of 77,875 equivalent barrels annually
Productivity	No major impact
Employment	No major impact; however, for plants closing, potential average of 4.6 jobs lost per plant closed
Market structure	Regulation could further concentrate a declining industry. Many small bulk plants today are marginal operations; further cost increases could result in some plant closings
Problem areas	Potential economic impact for small bulk plant operations. Regulation could cause further market imbalances. Control efficiency of cost effective alternative has not been effectively demonstrated
VOC emission after control	4,000 tons per year
Cost effectiveness of control	$289 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Hydrocarbon Control Strategies for Gasoline Marketing, EPA-450/3-78-017.

National Petroleum News Fact Book, 1967, McGraw Hill, Mid-May 1976.

National Petroleum News Fact Book, 1977, McGraw Hill, Mid-May 1977.

National Petroleum News Fact Book, 1978, McGraw Hill, Mid-June 1978.

Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013, September 1976.

Stage I Vapor Recovery and Small Bulk Plants in Washington, D.C., Baltimore, Maryland and Houston/Galveston, Texas, EPA 340/1-77-010, April 1977.

Evaluation of Top Loading Vapor Balance Systems for Small Bulk Plants, EPA 340/1-77-014, April 1977.

Regulatory Guidance for Control of Volatile Organic Compound Emissions form 15 Categories of Stationary Sources, EPA 905/2-78-001, April 1978.

Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources, PB-236 921, Environmental Protection Agency, September 1974.

Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA 450/2-77-035, December 1977.

Memorandum "Meeting with EPA and Others on Bulk Plant Vapor Recovery," National Oil Jobbers Council, Mr. Bob Bassman, Counsel, March 21, 1978.

Letter to Mr. William F. Hamilton, Economic Analysis Branch, United States Environmental Protection Agency, from California Independent Oil Marketers Association, February 28, 1978.

Private conversation with Mr. Clark Houghton, Missouri Bulk Plant Operator.

Private conversation with Mr. D. L. Adams, Phillips Petroleum, Towson, Maryland.

Private conversation with Mr. Robert Schuster, bulk plant operator in Escondido, California.

Private conversation with Mr. Burton McCormick, bulk plant operator in Santa Barbara, California.

"The Lundburg, Letter," Pele-Drop, North Hollywood California.

"1978 Marketing Directory and Yearbook," Michigan Petroleum Association, 1978.

Private conversation with Mr. William Deutsch, Illinois Petroleum Marketers Association, Springfield, Illinois.

15.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR STORAGE OF PETROLEUM LIQUIDS IN FIXED-ROOF TANKS IN THE STATE OF MICHIGAN

15.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR STORAGE OF PETROLEUM LIQUIDS IN FIXED-ROOF TANKS IN THE STATE OF MICHIGAN

This chapter presents a detailed analysis of the impact of implementing RACT controls for the storage of petroleum liquids in fixed-roof tanks. The major sections of the chapter include:

- Specific methodology and quality of estimates
- Technical characteristics of fixed-roof tanks and VOC emission control technology
- Profile of statewide fixed-roof tank industry and estimated annual VOC emissions
- Cost of controlling VOC emissions
- Economic impact.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of fixed-roof storage tanks, interviews and analysis.

15.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining:

- Technical characteristics of fixed-roof tanks
- Profile of fixed-roof tanks
- VOC emissions
- Cost of vapor control systems
- Economic impact of emission control.

For storage of petroleum liquids in fixed-roof tanks, the quality of these estimates is discussed in the last part of this section.

15.1.1 Technical Characteristics of Fixed-Roof Tanks

The technical characteristics of fixed-roof tanks and processes for controlling their emissions were obtained mainly from the RACT guideline entitled Control of Volatile Organic Emissions from Storage of Petroleum Liquids in Fixed-Roof Tanks, EPA-450/2-77-036, and from several other studies of fixed-roof tanks listed in the reference section of this report.

15.1.2 Profile of Fixed-Roof Tanks

The Michigan Department of Natural Resources provided a listing of fixed-roof tanks greater than 40,000-gallon capacity used for storing petroleum liquids from the emission inventory. Capacity of each tank as well as the type of petroleum liquid stored were also provided. Annual statewide throughput was calculated based on a turnover rate of 30 times per year. These data form the basis for calculating statewide VOC emissions in Michigan.

15.1.3 VOC Emissions

Statewide VOC emissions were calculated for petroleum liquids stored in fixed-roof tanks in Michigan based on the emission factors for working and breathing losses of various types of petroleum liquids. The emission factors were obtained from Compilation of Air Pollution Emission Factors, AP-42, U.S. Environmental Protection Agency. Tank capacity, fuel type and number of tanks were provided by the Michigan Department of Natural Resources.

15.1.4 Cost of Vapor Control Systems

The costs of vapor control systems were developed by:

- Determining the type of control system
- Developing installed capital costs for each tank
- Developing total annual costs of control systems for the number of tanks in the state including:
    - Installed capital cost
    - Direct operating costs
    - Annual capital charges
    - Petroleum liquid credit
    - Net annual cost
- Aggregating costs to the total industry in Michigan.

Costs were determined from analyses of the following studies:

- Control of Volatile Organic Emissions from Storage of Petroleum Liquids in Fixed-Roof Tanks, EPA-450/2-77-036
- Benzene Emission Control Costs in Selected Segments of the Chemical Industry, prepared for Manufacturing Chemists Association by Booz, Allen & Hamilton Inc., June 12, 1978

and from interviews with petroleum marketers' associations, petrochemical manufacturers and vapor control equipment manufacturers.

The application of the estimated cost of control to Michigan required a profile of fixed-roof tanks for storing petroleum liquids for the state, showing the capacity of each tank and the type of petroleum liquid being stored. These data were provided by the Michigan Department of Natural Resources for fixed-roof tanks greater than 40,000 gallon capacity.

15.1.5 Economic Impact of Emission Control

The economic impact of emission control for equipping fixed-roof tanks used for storing petroleum liquids can be determined only in terms of the statewide cost of controls. Since several industries use fixed-roof tanks, economic impacts on individual industries depend on the extent to which the industries must bear the increased cost. The economic impact analysis in this report is, therefore, limited to estimating statewide costs of controls and qualitatively assessing the potential impacts of these costs on various industries.

15.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls for fixed-roof tanks in Michigan. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 15-1, on the following page, rates each study output listed and the overall quality of the data.

Exhibit 15-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics	●		
Emissions			●
Cost of emissions control		●	
Statewide costs of emissions		●	
Economic impact			●
Overall quality of data		●	

Source: Booz, Allen & Hamilton Inc.

15.2 TECHNICAL CHARACTERISTICS OF FIXED-ROOF TANKS FOR STORING PETROLEUM LIQUIDS

This section describes the technical characteristics of fixed-roof tanks for storing petroleum liquids, the sources and types of VOC emitted by these tanks, the control measures for reducing VOC emissions from fixed-roof tanks and RACT guidelines.

15.2.1 Characteristics of Fixed-Roof Tanks for Storing Petroleum Liquids

Fixed-roof tanks consist of a cylindrical steel shell with a permanently affixed roof as characterized in Exhibit 15-2, on the following page. The roof design may vary from cone shape to flat. The fixed-roof tank is the least expensive type of storage tank to construct and is generally considered to be the minimum acceptable standard for storage of petroleum liquids. The tank is designed to operate at only slight internal pressure or vacuum.

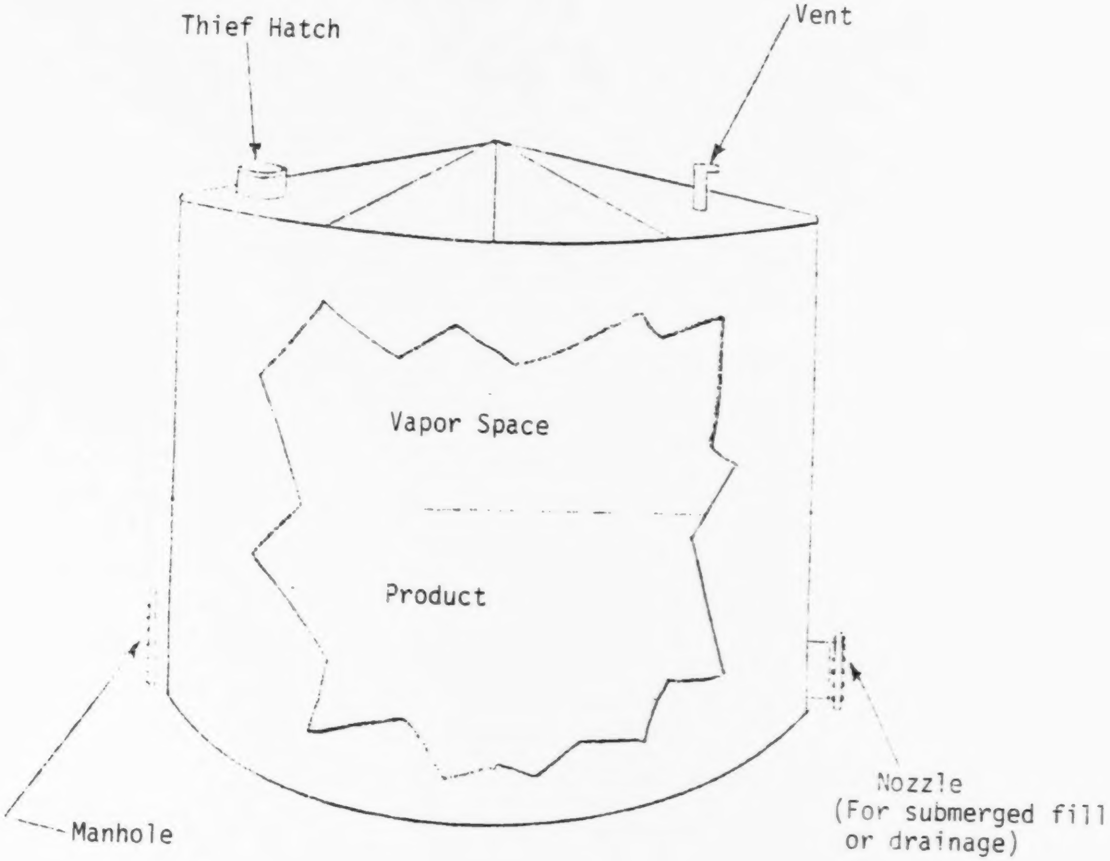
Fixed-roof tanks greater than 40,000-gallon capacity and containing petroleum liquids greater than 1.52 psia are the specific fixed-roof tanks under analysis in this report. These tanks are used for storing petroleum liquids at refineries, bulk terminals and tank farms, and along pipelines. These tanks are generally loaded by submerged fill and are unloaded into tank cars, tank trucks, ships, barges or pipeline.

The processes of petroleum liquid storage, tank loading and unloading are a major source of VOC emissions in Michigan. Specific sources and types of emissions from such tanks are discussed in the paragraphs which follow.

15.2.2 Sources and Types of VOC Emissions from Fixed-Roof Storage Tanks

VOC emissions result from the process of storing petroleum liquids in fixed-roof storage tanks and loading and unloading tanks with petroleum liquids. Fixed-roof tanks are designed to operate at only slight internal pressure or vacuum, and as a result the emissions from storage, filling and emptying can be appreciable.

Exhibit 15-2
U.S. Environmental Protection Agency
TYPICAL FIXED ROOF TANK


Thief Hatch
Vent
Vapor Space
Product
Manhole
Nozzle
(For submerged fill
or drainage)

Source: Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001, U.S. Environmental Protection Agency, April 1978

15.2.2.1 Emissions from Petroleum Liquid Storage

Emissions from petroleum liquid storage, referred to as breathing losses, occur from changes in temperature and pressure in the storage tank. Vapors are expelled from the tank when temperature and barometric pressure changes cause expansion and contraction of the volatile petroleum liquid. These VOC emissions or losses occur in the absence of any liquid level change in the tank. Breather valves (pressure vacuum) are installed on many fixed-roof tanks to prevent vapors from escaping to the atmosphere because of small changes in temperature and barometric pressure or very small fluctuations in liquid level. These vents, however, will vent vapors to the atmosphere during normal filling and draw air into the tank during emptying.

15.2.2.2 VOC Emissions from Filling and Emptying Storage Tanks

VOC emissions resulting from filling and emptying storage tanks are referred to as "working losses." As a tank is filled, the vapor-laden air in the airspace between the liquid and the tank top is displaced to the atmosphere through breather vents.

Emptying losses occur when air drawn into the tank through the breather vent becomes saturated with hydrocarbon vapor and expands such that the volume of the vapor-laden air exceeds the capacity of the vapor space.

Additional VOC emissions occur during tank cleaning and from any corrosion spots or deterioration in the tank.

15.2.3 Techniques for VOC Emission Control

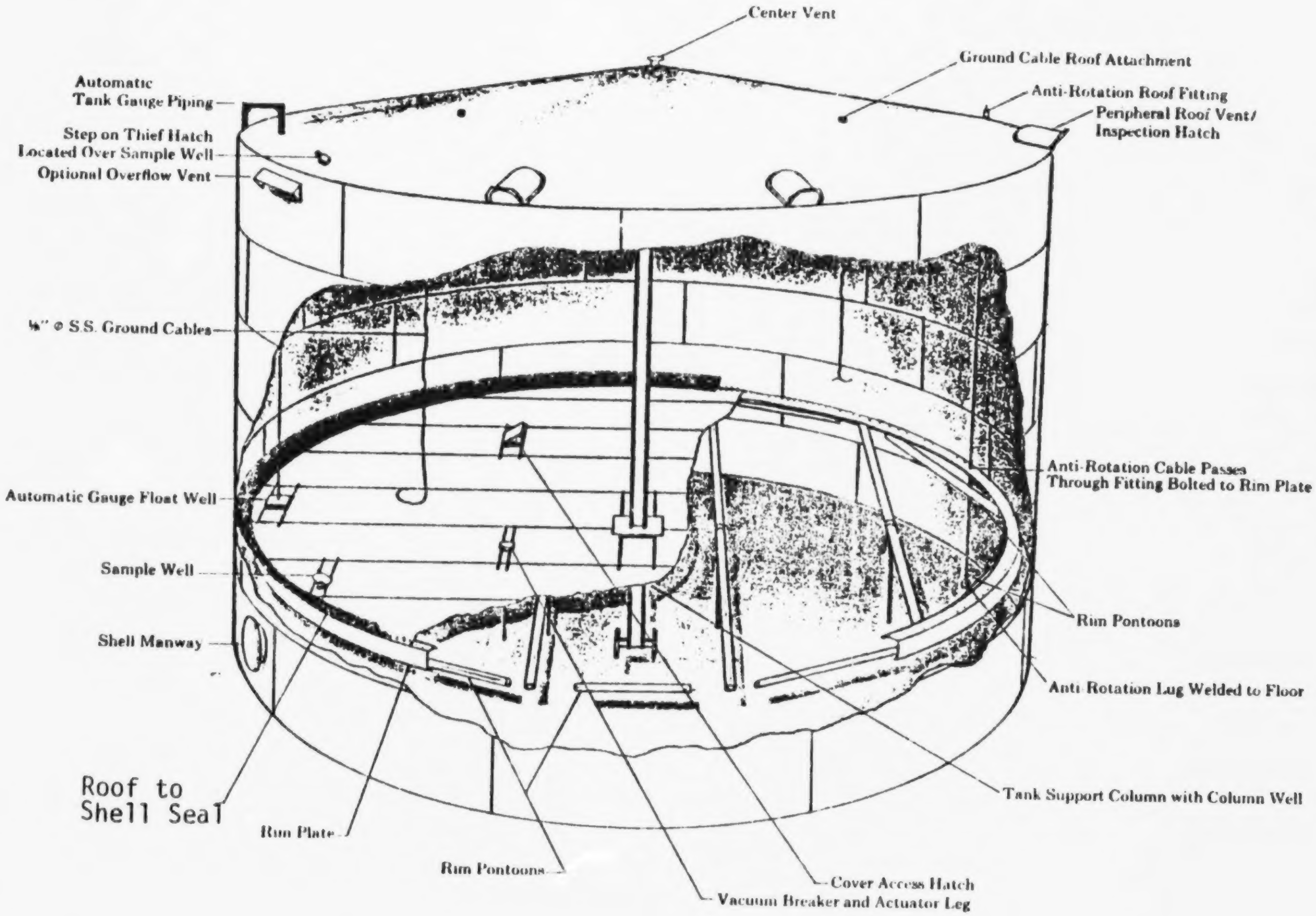
Fixed-roof tank emissions are most readily controlled by the installation of internal floating roofs. An internal floating roof for fixed-roof tanks is a cover floating on the liquid surface inside the tank, rising and falling with the liquid level. Exhibit 15-3, on the following page, is a schematic of a typical fixed-roof tank equipped with an internal floating roof or cover. There are two types of internal floating roofs:

- A pan-type steel floating roof
- A nonferrous floating roof made of aluminum or polyurethane.

Exhibit 15-3

U.S. Environmental Protection Agency

SCHEMATIC OF TYPICAL FIXED-ROOF TANK
WITH INTERNAL FLOATING COVER


Center Vent
Ground Cable Roof Attachment
Anti-Rotation Roof Fitting
Peripheral Roof Vent/ Inspection Hatch
Automatic Tank Gauge Piping
Step on Thief Hatch Located Over Sample Well
Optional Overflow Vent
⅛" ⌀ S.S. Ground Cables
Anti-Rotation Cable Passes Through Fitting Bolted to Rim Plate
Automatic Gauge Float Well
Sample Well
Rim Pontoons
Shell Manway
Anti Rotation Lug Welded to Floor
Tank Support Column with Column Well
Roof to Shell Seal
Rim Plate
Rim Pontoons
Cover Access Hatch
Vacuum Breaker and Actuator Leg

Source: Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001, U.S. Environmental Protection Agency, April 1978

The fixed roof protects the internal floating roof and seal from deterioration from climatological effects and eliminates the possibility of the floating roof sinking from the weight of rain or snow loads.

A closure device must be used to seal the gap between the tank shell and the internal floating roof around the roof perimeter. Special materials are available for the closure device in a wide range of designs to accommodate the entire spectrum of petroleum liquids. Exhibit 15-4, on the following page, illustrates several typical internal floating roofs and perimeter closure seals.

Other modifications may need to be made to the fixed-roof tank before it is equipped with an internal floating roof. Tank shell deformations and obstructions may require correction; special structural modifications (such as bracing, reinforcing and plumbing vertical columns) may be necessary. Anti-rotational guides should be installed to keep the internal floating roof openings in alignment with the fixed-roof openings. Special vents are installed on the fixed roof or on the walls at the top of the shell to minimize the possibility of VOCs approaching the flammable range in the vapor space.

15.2.4 RACT Guideline for VOC Emission Control

The RACT guidelines call for installation of an internal floating roof for fixed-roof tanks storing greater than 40,000 gallons of petroleum liquids with a true vapor pressure that exceeds 1.52 psia. The guidelines do not apply to storage tanks equipped with external floating roofs or to storage tanks having capacities less than 416,000 gallons used to store crude oil and condensate prior to lease custody transfer.[1]

It is expected that the State of Michigan will prepare legislation for the storage of petroleum liquids which is modeled after the RACT guidelines.

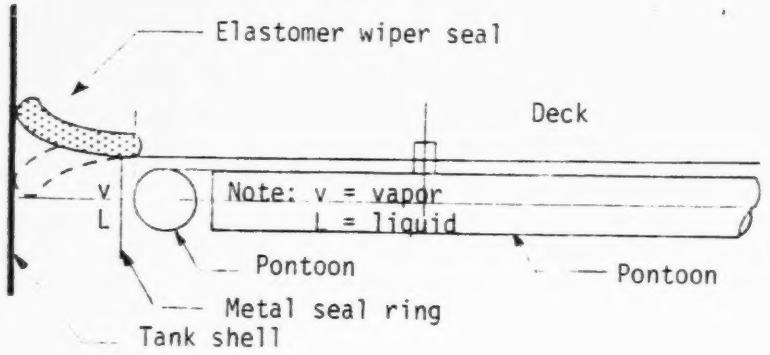
---

[1] "Custody transfer" means the transfer of produced crude oil and/or condensate, after processing and/or treating in the production operations, from storage tanks or automatic transfer facilities to pipelines or any other forms of transportation.

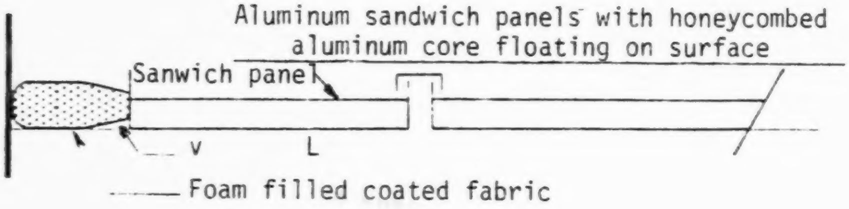
Exhibit 15-4

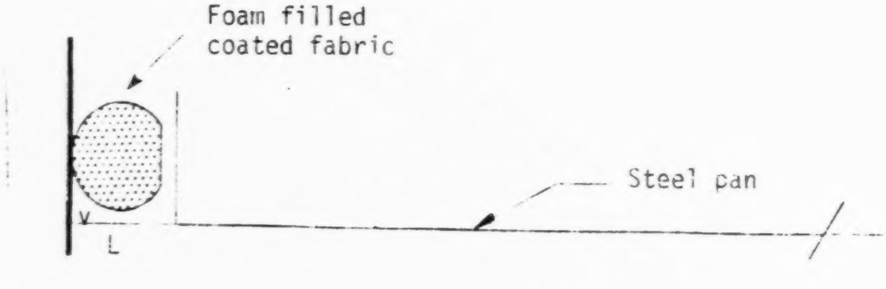
U.S. Environmental Protection Agency
TYPICAL FLOTATION DEVICES AND PERIMETER SEALS FOR INTERNAL FLOATING COVERS AND COVERED FLOATING ROOF

Aluminum deck supported above liquid by tubular aluminum pontoons


Elastomer wiper seal
Deck
v
L
Note: v = vapor
L = liquid
Pontoon
Pontoon
Metal seal ring
Tank shell

Aluminum sandwich panels with honeycombed aluminum core floating on surface


Sanwich panel
v
L
Foam filled coated fabric


Foam filled
coated fabric
Steel pan
v
L

Source: Based on Annex A, API Publication 2519, Second Edition

15.3 PROFILE OF FIXED-ROOF TANKS FOR STORING PETROLEUM LIQUIDS AND ESTIMATED VOC EMISSIONS

This section contains a profile of fixed-roof tanks used for storing petroleum liquids in the State of Michigan and the estimated annual VOC emissions from these tanks.

The Michigan Department of Natural Resources compiled a list of fixed-roof tanks from their emissions inventory. The capacity of each tank and the the type of petroleum liquid stored were provided in the listing. In summary, there are 161 fixed-roof tanks greater than 40,000 gallon capacity, not equipped with an internal floating roof in Michigan. The total storage capacity of these tanks is 182 million gallons, and the annual throughput of petroleum liquid is estimated to be 5.47 billion gallons.

It is estimated that annual VOC emissions from the storage of petroleum liquids in fixed-roof tanks in Michigan are 20,437 tons per year.

It is further estimated that these emissions could be reduced by 90 percent or to 2,044 tons per year by implementing RACT in Michigan.

15.4 COST OF CONTROLLING VOC EMISSIONS

This section presents a cost analysis of equipping fixed-roof tanks used for storing petroleum liquids with internal floating roofs as a means for controlling VOC emissions.

The costs for emission control equipment include:

- Installed capital cost, including parts and labor
- Annual capital charges, estimated to be 25 percent of installed capital cost and including costs for depreciation, interest, maintenance, taxes and insurance
- Annualized direct operating costs, estimated to be 2 percent of installed capital cost and including costs for inspection and recordkeeping
- Annual petroleum liquid credit, calculated by multiplying emission reduction by the volume of the petroleum liquid divided by the liquid density
- Net annualized costs, the sum of the capital charges and direct operating costs less the petroleum liquid credit.

Capital costs were determined for each tank from the graph in Exhibit 15-5, on the following page. This graph was prepared by Booz, Allen based on interviews with petroleum refineries, petrochemical manufacturers, tank manufacturers and emission control equipment manufacturers. Total installed capital cost, including labor, is two times the value given on the graph. All costs are for 1977.

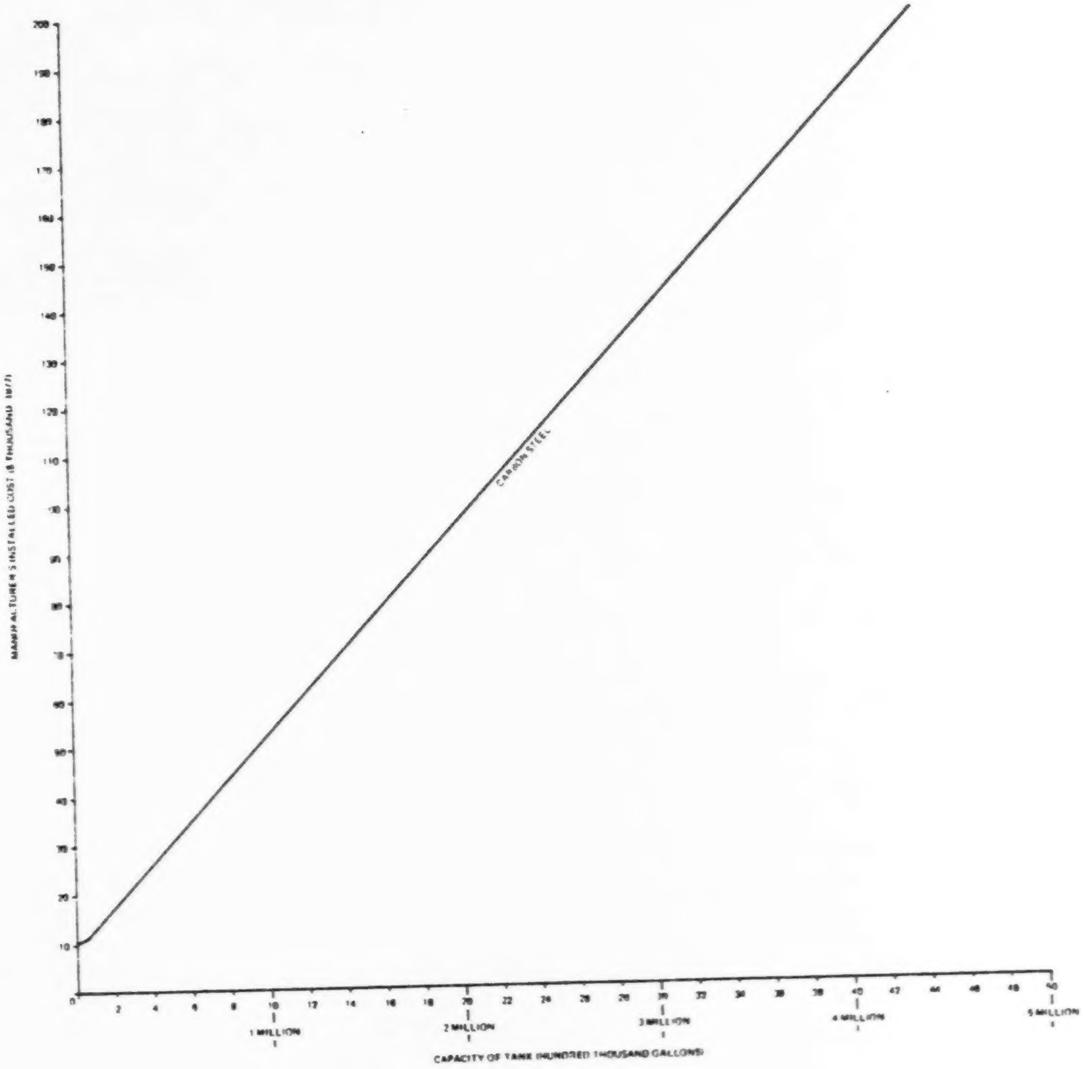
A summary of the costs aggregated statewide from the emission control of petroleum liquids stored in fixed-roof tanks is shown in Exhibit 15-6, following Exhibit 15-5. The total installed capital cost for equipping the 161 fixed-roof tanks in Michigan with internal floating roofs exceeds $20 million. The net annualized cost exceeds $3 million, which equals $170 per ton of emissions reduced.

Exhibit 15-5

U.S. Environmental Protection Agency

INSTALLED COST OF SINGLE SEAL FLOATING ROOF TANKS

(Prices Approximate)



Source: Communications with Ultra-Float Inc.; Booz, Allen & Hamilton Inc. analysis

Exhibit 15-6

U.S. Environmental Protection Agency
VOC EMISSIONS CONTROL COSTS FOR
STORAGE OF PETROLEUM LIQUIDS IN
FIXED-ROOF TANKS IN MICHIGAN

SUMMARY OF COSTS

Number of tanks	161
Total capacity (millions of gallons)	182
Estimated annual throughput (billions of gallons)	5.47
Uncontrolled emissions (tons per year)	20,437
Emissions reduction (tons per year)	18,393
Controlled emissions (tons per year)	2,044
Installed capital cost ($ millions, 1977)	20.048
Annualized capital charges ($ millions, 1977)	5.01
Annualized direct operating costs ($ thousands, 1977)	400.96
Annual petroleum credit ($ millions, 1977)	2.280[a]
Net annualized cost ($ millions, 1977)	3.133
Annualized cost per ton of emissions reduced ($, 1977)	170

---

[a] Assume value of petroleum liquid saved is $0.39 per gallon and density of petroleum liquid is 6.3 pounds per gallon.

Source: Booz, Allen & Hamilton Inc.

15.5 ECONOMIC IMPACT

This section discussed the economic impact of equipping fixed-roof tanks used for storing petroleum liquids with internal floating roof to control VOC emissions. The impacts analyzed include: total cost statewide; identification of industries that may be affected and their ability to raise the capital needed for the controls; and effects on employment, productivity and market structure.

- Total cost in Michigan—An estimated $20 million will be required statewide in Michigan to equip fixed-roof tanks for storing petroleum liquids with internal floating roofs. This represents approximately 0.01 percent of the value of petroleum liquids sold in Michigan and 0.01 percent of the value of wholesale trade in Michigan.
- Industries affected—Fixed-roof tanks, greater than 40,000 gallons, used for storing petroleum liquids are owned by major oil companies, large petrochemical firms and bulk gasoline tank terminal companies. It is predicted that these companies will be able to meet the necessary capital requirements.
- Employment—No change in employment is predicted from the implementation of RACT.
- Productivity—No change in worker productivity will result from the implementation of RACT.
- Market structure—No change in market structure will result from implementation of RACT.

* * * *

Exhibit 15-7, on the following page, presents a summary of the findings in this report.

Exhibit 15-7

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR STORAGE OF PETROLEUM LIQUIDS IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected storage tanks	160
Indication of relative importance of industrial section to state economy	The annual throughput was an estimated 5.5 billion gallons
Current industry technology trends	Internal floating roof tanks utilizing a double seal have been proven to be more cost effective
1977 VOC emissions (actual)	20,400 tons per year
Preferred method of VOC cotrol to meet RACT guidelines	Single seal and internal floating roof

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$20 million
Annualized cost (statewide)	$3.1 million
Price	Assuming a "direct cost pass-through"—less than $0.001 per gallon of throughput
Energy	Assuming 90 percent reduction of current VOC level, the net energy savings represent an estimated savings of 140,000 equivalent barrels of oil annually
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
Problem area	Potential availability of equipment to implement RACT standard
VOC emission after RACT control	2,000 tons per year
Cost effectiveness of RACT control	$170 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Benzene Emission Control Costs in Selected Segments of the Chemical Industry, prepared for Manufacturing Chemists Association by Booz, Allen & Hamilton Inc., June 12, 1978.

Control of Volatile Organic Emission from Storage of Petroleum Liquids in Fixed-Roof Tanks, EPA-450/2-77-036, U.S. Environmental Protection Agency, December 1977.

Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001, U.S. Environmental Protection Agency, April 1978.

Revision of Evaporative Hydrocarbon Emission, PB-267 659, Radian Corporation, August 1976.

16.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT STAGE I FOR GASOLINE SERVICE STATIONS IN THE STATE OF MICHIGAN

16.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT STAGE I FOR GASOLINE SERVICE STATIONS IN THE STATE OF MICHIGAN

This chapter presents a detailed analysis of implementing RACT Stage I controls for gasoline service stations in the State of Michigan. The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation of the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic implications
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of gasoline service station vapor recovery, interviews and analysis.

16.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for gasoline service stations in the State of Michigan.

The quality of the estimates based on a three point scale is described in detail in the latter part of this section.

16.1.1 Industry Statistics

Industry statistics on gasoline service stations were obtained from several sources. All data were converted to a base year, 1977, based on specific scaling factors. The number of service stations for 1977 was reported in the National Petroleum News Factbook, 1978. The number of "non-service stations" was estimated to be an additional 137 percent of the number of service stations in the state based on a study entitled, The Economic Impact of Vapor Recovery Regulations on the Service Station Industry[1]. The number of employees in 1977 was determined by multiplying the national average number of employees per service station (3.5) by the number of establishments in the state which was reported in 1977. The number of employees at "non-service stations" is estimated to be two employees per facility. The number of gallons of gasoline sold in 1977 in the state was reported in the National Petroleum News Factbook, 1978, for 1977. Sales, in dollars, of motor gasoline for 1977 were estimated by multiplying the number of gallons of gasoline sold in 1977 by the average national service station price (excluding tax) in 1977 (50.7¢/gallon) which was reported in the National Petroleum News Factbook, 1978.

16.1.2 VOC Emissions

Emissions from gasoline service stations (including emissions from underground tank breathing, underground tank filling, vehicle refueling and spillage) in Michigan were calculated by multiplying emission factors by gasoline throughput statewide. The emission factors were reported in Hydrocarbon Control Strategies for Gasoline Marketing Operations, EPA-450/3-78-017, April 1978. For purposes of this study it was assumed, based on interviews in Michigan, that 90 percent of the gasoline service stations currently use submerged loading of underground storage tanks and the remaining 10 percent of the facilities use splash filling.

---

[1] Prepared for the Department of Labor, OSHA, C7991, March 1978, pp. 4-7.

16.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions from gasoline service stations are described in Design Criteria for Stage I Vapor Control Systems Gasoline Service Stations. This document provides data on alternative methods available for controlling VOC emissions from gasoline service stations. Several studies of VOC emission control were also analyzed in detail and interviews with petroleum trade associations, gasoline service station operators and vapor control equipment manufacturers were conducted to ascertain the most likely types of equipment which would be used in gasoline service stations in Michigan. The specific studies analyzed were: Economic Impact of Stage II Vapor Recovery Regulations: Working Memoranda, EPA-450/3-76-042; A Study of Vapor Control Methods for Gasoline Marketing Operations, PB-246-088, Radian Corporation; Reliability Study of Vapor Recovery Systems at Service Stations, draft, Illinois Environmental Protection Agency.

16.1.4 Cost of Vapor Control Systems

The costs of vapor control systems were developed by:

- Developing costs of two different control systems for a model service station including:
    - Installed capital cost
    - Direct operating costs
    - Annual capital costs
    - Gasoline credit
    - Net annual cost
- Aggregating costs to the statewide gasoline station service industry.

Costs were determined from analyses of the studies listed previously and from interviews with petroleum marketers' associations, gasoline service station operators, and vapor control equipment manufacturers.

It was assumed that 75 percent of the gasoline dispensing facilities would install coaxial or concentric vapor balance systems and the remaining 25 percent would install the two point vapor balance system. Costs for the two systems are assumed to be represented by the costs developed for the model service station. Statewide costs were extrapolated from the model costs. It was assumed that all gasoline service stations in the state will be required to meet the guidelines.

16.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements needed to implement RACT; assessing the feasibility of instituting RACT controls in terms of capital and equipment availability; comparing the direct costs of RACT control to various state economic indicators; and assessing the secondary impacts on market structure, employment and productivity resulting from implementation of RACT controls.

16.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on gasoline service stations. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 16-1, on the following page, rates each study output and the overall quality of the data.

Exhibit 16-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics	●		
Emissions		●	
Cost of emissions control		●	
Statewide costs of Emissions			●
Economic impact		●	
Overall quality of data		●	

Source: Booz, Allen & Hamilton, Inc.

16.2 INDUSTRY STATISTICS

Industry characteristics, statistics and business trends for gasoline service stations are presented in this section. The discussion includes a description of the number of facilities and their characteristics, a comparison of the size of the service station industry to state economic indicators, a historical characterization and description of the industry and an assessment of future industry patterns. Data in this section form the basis for assessing the impact on this industry of implementing RACT to VOC emissions from gasoline service stations in Michigan.

16.2.1 Size of Industry

There were an estimated 7,251 gasoline service stations in Michigan in 1977, and an additional estimated 9,934 "non-service stations" which include gasoline dispensing facilities such as marinas, general aviation facilities, commercial and industrial gasoline consumers and rural operations with gas pumps. Industry sales were in the range of $2.48 billion with a yearly throughput of 4.888 billion gallons of gasoline. The estimated number of employees in 1977 was 25,400 employees in service stations and 19,868 employees in "non-service stations" for a total of 45,300 employees. These data and the sources of information are summarized in Exhibit 16-2, on the following page. Total capital investments by the service station industry were not identified, although in general gasoline service station operators make investments in plant and equipment to replace worn-out facilities and equipment, modernize the establishments or improve operating efficiencies.

16.2.2 Comparison of Industry to State Economy

The gasoline service station industry is compared to the economy of the State of Michigan in this section by comparing industry statistics to state economic indicators. Employees in the gasoline service station industry represent approximately 0.78 percent of the total state civilian labor force of Michigan. The value of gasoline sold from gasoline service stations represented approximately 8 percent of the total value of retail trade in Michigan in 1977.

Exhibit 16-2

U.S. Environmental Protection Agency

INDUSTRY STATISTICS FOR GASOLINE SERVICE STATIONS IN MICHIGAN

Number of Facilities		Number of Employees		Sales	Gasoline Sold
Service Stations	Non-Service Stations	Service Stations	Non-Service Stations	($Billion, 1977)	(Billions of Gallons)
7,251[a]	9,934[b]	25,400[c]	19,868[d]	2.48[e]	4.888[f]

---

a. National Petroleum News Fact Book, 1978.

b. Includes gasoline dispensing facilities such as marinas, general aviation facilities, commercial and industrial gasoline consumers and rural operations with gas pumps.

c. Estimate based on the ratio of the number of employees to the number of establishments nationally in 1977.

d. Estimate based on two employees per facility.

e. Number of gallons of motor gasoline sold in 1977 multiplied by the national service station price in 1977 (50.70¢/gallon), National Petroleum News Fact Book, 1978.

f. National Petroleum News Factbook, 1978, p. 78

Source: Booz, Allen & Hamilton Inc.

16.2.3 Characterization of the Industry

Gasoline service stations and retail outlets are the final distribution point in the petroleum marketing network, as shown in Exhibit 16-3, on the following page. Several types of gasoline service stations and retail gasoline outlets offer services ranging from self-service to full service. A general classification of service stations in the United States is listed in Exhibit 16-4, following Exhibit 16-3, along with the percentage of each type of station existing nationally in 1977. Service station ownership may be characterized by one of the following four arrangements:

- Supplier owned/supplier operated
- Supplier owned/dealer operated
- Dealer owned/dealer operated
- Convenience store.

An estimated 26 percent of service stations are owned and operated by the station's supplier of gasoline, 44 percent are owned by the supplier and leased to a dealer, and 30 percent are owned and operated by an independent dealer.[1]

Gasoline marketing is characterized by high fixed costs, with operations varying by degree of labor intensity. Conventional service stations (service bay with mechanics on duty and nongasoline automotive items available) are the most labor intensive, while self-service "gas and go" stations exemplify low labor intensity.

The number of gasoline service stations nationally has been declining since 1972, while the throughput per station has been rising. This trend is also evident in Michigan and is predicted to continue. It is estimated that, by 1980, one-half the gasoline stations in the country will be totally self-service.[2]

---

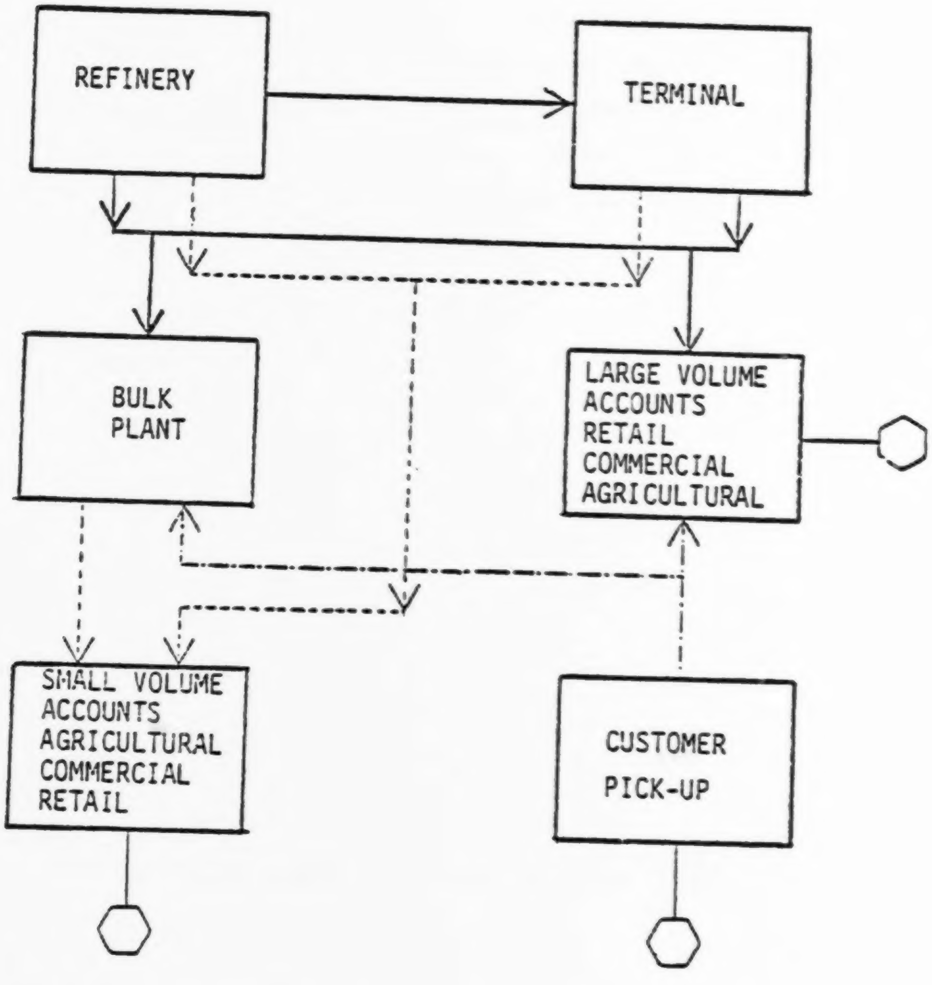
[1] Economic Impact of State II Vapor Recovery Regulations: Working Memoranda, EPA 450/2-76-042, November 1976, p. 6.

[2] *Ibid.*, p. 2.

Exhibit 16-3

U.S. Environmental Protection Agency

GASOLINE DISTRIBUTION NETWORK


REFINERY
TERMINAL
BULK PLANT
LARGE VOLUME ACCOUNTS RETAIL COMMERCIAL AGRICULTURAL
SMALL VOLUME ACCOUNTS AGRICULTURAL COMMERCIAL RETAIL
CUSTOMER PICK-UP

——→ Typical delivery route of truck-trailer

– – –→ Typical delivery route of account truck

–·–·→ Typical transaction with consumer coming to supplier

⬡ Final Product Usage

Source: Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013, p. 3-2.

Exhibit 16-4
U.S. Environmental Protection Agency
CLASSIFICATION OF SERVICE STATIONS

Type of Service Station	Percentage of Population
Full-service	41.8
Self-service	9.4
Split island	37.3
Convenience store	4.4
Car wash	4.5
Truck stop	1.9
Mini service	0.7
TOTAL	100.0

Source: National Petroleum News Fact Book, 1978, p. 106

16.2.4 Gasoline Prices

Gasoline prices vary among types of gasoline stations within a geographical area. Convenience stores are apt to have higher pump prices than large self-service "gas and go" stations. The pump price less the dealer tank wagon price represents the gross margin on a gallon of gasoline. Gasoline service station operating costs then must come out of the gross margin for gasoline as well as the gross margin for other products which may be sold at the service station. Operating costs vary substantially among the various types of service stations. It is reported that some service stations operate with nearly zero net margin or profit, while others may enjoy up to four to five cents per gallon profit. Sufficient data are not available on service stations in Michigan to present a thorough analysis of existing price structures and degree of competition in the industry within the State.

16.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on gasoline service station operation, estimated VOC emissions from service station operations in the state, the extent of current control in use, the vapor control requirements of RACT and the likely alternatives which may be used for controlling VOC emissions from service stations in Michigan.

16.3.1 Gasoline Service Station Operations

Gasoline service stations are the final distribution point in the gasoline marketing network. Gasoline is delivered from bulk gasoline plants via account truck or from the bulk gasoline tank terminal via trailer-transport truck, stored in underground storage tanks, and subsequently dispensed via pump to motor vehicles. Service stations are characterized by their services and business operations: full service stations, split island stations, self-service stations and convenience store operations. In full service stations, attendants offer all services, including gasoline pumping and mechanical check-ups. If fuel is used at any of the last three classes of stations, the customers may fill up the tanks themselves. In split island stations, both self-service and full service are offered. At the two remaining types of stations, only self-service is available.

16.3.1.1 Facilities

Equipment at gasoline dispensing facilities used in handling gasoline are: gasoline storage tanks, piping and gasoline pumps. The most prevalent type of gasoline storage tank is the underground tank. It is assumed that there are typically three storage tanks per facility based on information in Hydrocarbon Control Strategies for Gasoline Marketing Operations, p. 2-17. Gasoline is dispensed to motor vehicles through pumps and there may be anywhere from one to twenty pumps per facility. Stage I vapor control regulations apply to the delivery of gasoline to the facility and the subsequent storage in underground tanks.

16.3.1.3 Operations

Uncontrolled VOC emissions at service stations come from loading and unloading losses from tank trucks and underground tanks, refueling losses from vehicle tanks and breathing losses from the underground tank vent. Stage I vapor control applies to tank truck unloading and working and breathing losses from underground storage tanks.

Tank trucks are unloaded into underground storage tanks either by splash loading or submerged loading. Splash loading results in more emissions than submerged loading.

More specifically, losses occur when:

- Organic liquids vaporize into the air that is drawn into the tank truck compartment during unloading of the tank truck.
- Vapors are displaced from the underground storage tank during tank loading.
- Changes in temperature and pressure in the underground storage tank result in vapors being vented to the atmosphere.

The control measures involve vapor balancing between the tank truck and storage tank and submerged filling of the gasoline storage tank. Vapor recovery systems are also available for emission control when combined with a vapor balancing system.

Since most storage tanks at gasoline service stations are relatively small and underground, it is unlikely that they are equipped with sophisticated control equipment. The breathing losses, therefore, can be controlled only by adjusting the pressure relief valve.

16.3.2 Emissions and Current Controls

This section presents the estimated VOC emissions from gasoline service stations in Michigan in 1977 and the current level of emission control already implemented in the state. Exhibit 16-5, on the following page, shows the total estimated emissions in tons per year from gasoline service stations in Michigan. Emissions, based on gasoline throughput, are estimated to be 45,018 tons per year. Emissions include emissions from underground tank breathing, underground tank filling, vehicle refueling and spillage.

Exhibit 16-5

U.S. Environmental Protection Agency
VOC EMISSIONS FROM GASOLINE SERVICE STATIONS

Estimated Number of Facilities	Average Yearly Throughput (Millions of Gallons)	Total Emissions (Tons/Year)
17,185	4,888	45,018

Source: Booz, Allen & Hamilton Inc.

It is assumed that 90 percent of the storage tanks loading is by submerge filling based on interviews.

16.3.3 RACT Guidelines

The RACT guidelines for Stage I VOC emission control from gasoline service stations require the following controls:

- Submerged fill of gasoline storage tanks
- Vapor balancing between the truck and the gasoline storage tank
- Proper operation and maintenance of equipment.

Exhibit 16-6, on the following page, summarizes the RACT guidelines for VOC emissions control from gasoline service stations.

16.3.4 Selection of the Most Likely RACT Alternative

Stage I control of VOC emissions from gasoline service stations is achieved using submerged filling of storage tanks and vapor balancing between the unloading of incoming tank trucks and the gasoline storage tanks. There are alternative means of achieving vapor balance based primarily on the method of connecting the vapor return line to the gasoline storage tank. The two primary methods for connecting vapor return lines, two points connection and coaxial or concentric connection (often referred to as tube-in-tube connection), are described in Sections 16.3.4.2 and 16.3.4.3.

16.3.4.1 Vapor Balance System

The purpose of the vapor balance system is to return displaced vapors from the underground gasoline storage tank to the tank truck during storage tank loading. There are two basic versions of vapor balancing for Stage I.

The "two point" method depicted in Exhibit 16-7, following Exhibit 16-6, shows a storage tank with two risers. One riser is for fuel delivery and the other is for returning vapors to the tank truck. The other method, "concentric or coaxial system," shown in Exhibit 16-8, employs a concentric liquid vapor return line, thus requiring only one tank riser.

Exhibit 16-6

U.S. Environmental Protection Agency
VOC EMISSION CONTROL TECHNOLOGY FOR
GASOLINE SERVICE STATIONS

Facilities Affected	Sources of Emissions	RACT Control Guidelines
Gasoline service stations and gasoline dispensing facilities	Storage tank filling and unloading tank truck	Stage I vapor control system, i.e. vapor balance system which returns vapors displaced from the storage tank to the truck during storage tank filling; and submerge filling

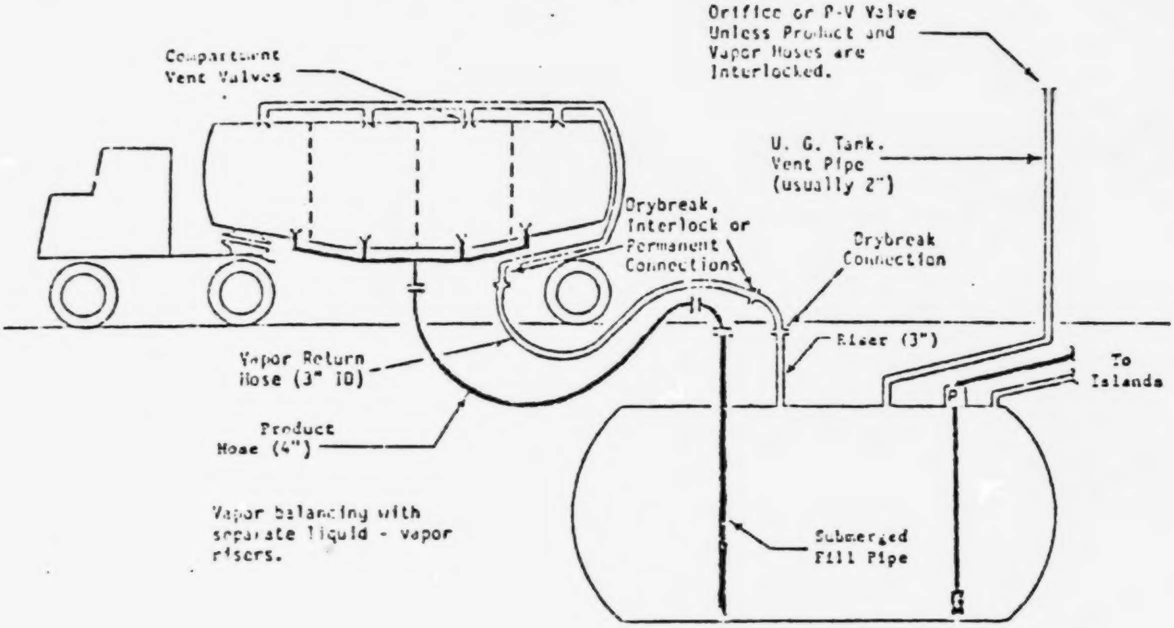
Source: Design Criteria for Stage I Vapor Control Systems, Gasoline Service Stations, U.S. EPA, November 1975.

Exhibit 16-7

U.S. Environmental Protection Agency

STAGE I VAPOR CONTROL SYSTEM -
VAPOR BALANCING WITH SEPARATE LIQUID-VAPOR RISERS

Reproduced from
best available copy.


Compartment
Vent Valves
Orifice or P-V Valve
Unless Product and
Vapor Hoses are
Interlocked.
U. G. Tank.
Vent Pipe
(usually 2")
Drybreak,
Interlock or
Permanent
Connections
Drybreak
Connection
Riser (3")
To
Islands
Vapor Return
Hose (3" ID)
Product
Hose (4")
Submerged
Fill Pipe
P

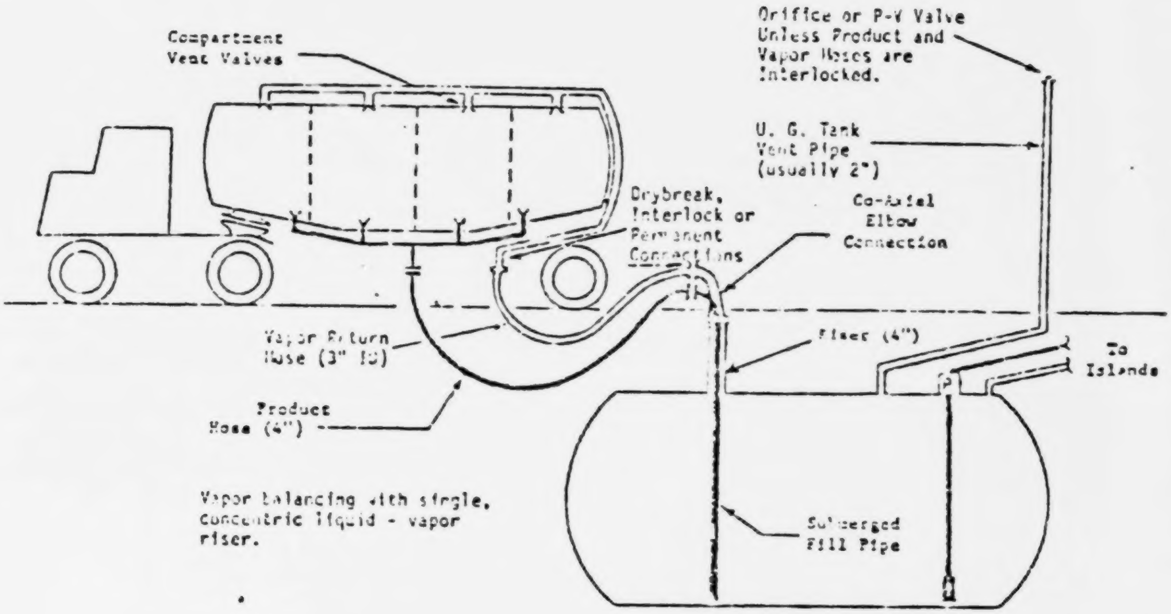
Vapor balancing with separate liquid - vapor risers.

Source: Design Criteria for Stage I Vapor Control Systems Gasoline Service Stations, U.S. EPA, November 1975.

Exhibit 16-8

U.S. Environmental Protection Agency

STAGE I VAPOR CONTROL SYSTEM -
VAPOR BALANCING WITH CONCENTRIC LIQUID-VAPOR RISER


Compartment Vent Valves
Orifice or P-V Valve Unless Product and Vapor Hoses are Interlocked.
U. G. Tank Vent Pipe (usually 2")
Drybreak, Interlock or Permanent Connections
Co-Axial Elbow Connection
Vapor Return Hose (3" ID)
Riser (4")
To Islands
Product Hose (4")
Submerged Fill Pipe

Vapor balancing with single, concentric liquid - vapor riser.

Source: Design Criteria for Stage I Vapor Control Systems Gasoline Service Stations, US. EPA, November 1975.

The vapor balance systems use flexible hoses carrying liquid gasoline from the tank truck down a drop tube to the underground storage tank. Entering liquid forces the air-hydrocarbon mixture in the storage tank out through a flexible vapor return hose to the tank truck. At the truck, the vapor return hose is connected to a piping manifold which is interconnected with the truck compartments by vents. The vents are opened selectively during truck unloading, allowing returning vapors from the underground tank to enter respective product compartments on the truck.

16.3.4.2 Two Point Vapor Balance System

The most effective method of transferring displaced vapors from the underground tank to the truck is by using a separate connection to the underground storage tank for the vapor return hose as shown in Exhibit 16-8. Equipment costs for this type of system are less expensive than for the coaxial or concentric system, although installation costs are considerably higher. U.S. EPA has tested this type of system to show that it complies with RACT requirements. It is estimated that 25 percent of the service stations would install the two point system, bearing a higher cost but achieving greater efficiency.

16.3.4.3 Concentric or Coaxial Vapor Balance Systems

At some gasoline service stations, a separate riser is not available on storage tanks or the gasoline service station operator does not wish to incur the additional installation expense to excavate to an unused entry to install a separate riser. For these cases, coaxial devices have been developed to remove vapors from the same opening through which the fuel is delivered.

As shown in Exhibit 16-8, a drop tube of smaller diameter is inserted in the existing fuel riser. The vapors exit through the annular space. A coaxial adaptor fits on the riser and provides connections for the fuel delivery hose and the vapor return hose. In the other system, the fuel and vapor passages are separated in a "Y" fitting which is permanently attached to the underground tank. The fittings for the hose connections are located in a conventional manhole. Most of these coaxial devices provide less cross-sectional area in the vapor return passage than do separate connectors and tend to reduce vapor recovery efficiency and gasoline storage tank fill rates to some extent. It is estimated that 75 percent of the gasoline service stations would install this type of system due to the lower installed cost of the system.

16.3.4.4 Manifolded Vent Lines

Several schemes have been used to manifold vents from two or more tanks to a common vapor hose connection. Manifolding may be above or below grade. A number of configurations have been developed for use with suitable vent restrictions. A three-way connector provides the most effective arrangement since connection of the vapor hose to the common connector blocks flow to the atmosphere and routes all displaced vapor to the tank truck. In any manifold piping system, care must be exercised to prevent contamination of "no-lead" gasoline products.

16.3.4.5 Drop Tubes for Submerged Filling

Submerged fill is required by Stage I vapor control. The submerged fill requirement means use of a drop tube extending to within six inches of the storage tank bottom. Under normal industry practices, a tube meeting this specification will always be submerged since the storage tanks are not pumped dry.

16.4 COST AND HYDROCARBON REDUCTION BENEFIT EVALUATIONS FOR STAGE I RACT REQUIREMENTS

Costs for VOC emission control equipment are presented in this section. The costs for a typical gasoline service station are described, followed by an extrapolation to the statewide industry.

16.4.1 Costs for Vapor Control Systems

The costs for vapor control systems were derived from analysis of the petroleum marketing trade association data and from previous cost and economic studies of gasoline service stations, and are summarized for a typical gasoline service station in Exhibit 16-9, on the following page. The cost of Stage I vapor control for a typical service station of 44,000 gallons per month throughput has been estimated as follows. Capital costs of installing the two point vapor-balance equipment at existing service stations are about $2,000 per station. This cost includes equipment costs ($300-$500) and installation ($1,300-$1,600).[1] The installed capital cost for a coaxial or concentric system is reported by U.S. EPA to be $150 to $200 per tank, including parts and labor. Annualized capital costs are estimated at 25 percent of installed capital cost and include interest, depreciation, taxes and maintenance. This cost analysis does not consider the cost of tank truck modification. The cost of modification of trucks to receive the displaced vapors is about $2,000-$3,000 per truck. It is assumed that the service station operator does not own the tank truck and, therefore, will not bear this cost.

Stage I vapor control at service stations will not increase direct annual operating costs. Gasoline credit is not included in Exhibit 16-9, but it will be included in the statewide costs in the next section. The net annualized cost for a typical gasoline service station with 44,000 gallons per month throughput is estimated to be $500 for the two point system and $150 for the concentric or coaxial system.

---

[1] Air Pollution Control Technology Applicable to 26 Sources of Organic Compounds, U.S. Environmental Protection Agency, May 27 1977. (This cost includes excavation and construction of manifolded storage tanks.)

Exhibit 16-9

U.S. Environmental Protection Agency
STAGE I VAPOR CONTROL COSTS FOR A TYPICAL GASOLINE SERVICE STATION

Description of Model Gasoline Station

Monthly Throughput (gallons)	48,000
Number of storage tanks	3

Costs
($, 1977)

	Two Point System	Coaxial or Concentric System
Installed capital cost	2,000	600
Annualized capital charges[a]	500	150
Direct operating cost	0	0
Net annualized cost	500	150

---

a. Twenty-five percent of installed capital cost. Includes depreciation, interest, taxes, insurance and maintenance.

Source: Booz, Allen & Hamilton Inc.

16.4.2 Extrapolation to the Statewide Industry

This section presents an extrapolation of vapor control costs to the statewide industry. An estimated 36 service stations and 3,576 nonservice stations may be exempted from the Michigan regulation since these facilities are deemed to have storage tanks of less than 2,000 gallon capacity. These facilities are excluded in the statewide cost analysis. Exempted facilities were estimated from national data presented in The Economic Impact of Vapor Recovery Regulations on the Service Station Industry, p. 47.

Exhibit 16-10, on the following page, shows the extrapolation of vapor control costs to the statewide industry based on the costs for a typical gasoline service station. It should be noted that actual costs to service station operators may vary depending on the type of control method and manufacturer's equipment selected by each service station operator.

The total cost to the industry for installing vapor control equipment is estimated to exceed $12.895 million. The amount of gasoline prevented from vaporizing using submerged filling of the gasoline storage tank is valued at $170,000 per year. The annual cost per ton of emissions controlled is estimated to be $170 per ton.

The distribution of the statewide costs and emissions reduction by the size of gasoline service stations based on throughput is shown in Exhibit 6-11, following Exhibit 6-10. Based on these data, gasoline dispensing facilities with throughput less than 24,000 gallons per month account for 45 percent of the estimated statewide cost of control but only 23 percent of the estimated emissions reduction for gasoline dispensing facilities.

Exhibit 16-10
U.S. Environmental Protection Agency
STATEWIDE COSTS FOR STAGE I VAPOR
CONTROL OF GASOLINE SERVICE STATIONS

SUMMARY OF COST

Number of potentially affected[a] facilities	13,573
Total annual throughput[b] (billions of gallons)	4.671
Uncontrolled emissions[c] (tons/year)	45,018
Emissions reduction[d] (tons/year)	17,862
Emissions after RACT control (tons/year)	27,156
Installed capital ($ millions)	12.90
Annual capital cost ($ millions)	3.22
Annual gasoline credit[e] ($ millions)	0.17
Net annualized cost ($ millions)	3.05
Net annualized cost per ton of emissions reduced ($ per ton/year)	170

---

a. Includes the estimated number of facilities with storage tanks over 2,000 gallons in capacity.

b. Estimated throughput from the potentially affected facilities only.

c. Total emissions including those facilities that may be exempted.

d. Estimated reduction based on reducing emissions from tank filling by employing submerged filling and vapor balancing.

e. Gasoline credit of $170,000 based on converting from splash fill to submerged fill and gasoline valued at $0.507 gallon.

Source: Booz, Allen & Hamilton Inc.

Exhibit 16-11

U.S. Environmental Protection Agency

STATEWIDE COSTS OF VAPOR CONTROL SYSTEMS BY SIZE OF GASOLINE DISPENSING FACILITY IN MICHIGAN

Gasoline Dispensing Facility Throughput (000 gallons per month)	Percentage[a] of Facilities	Percentage[a] of Volume	Current Estimated Annual VOC Emissions (tons per year)	Estimated Annual VOC Emission After RACT Control (tons per year)	Net VOC Emission Reduction (tons per year)	Percentage of Total VOC Emissions Reduced	Estimated Annual Cost ($, millions, 1977)	Percentage of Total Annual Cost	Net Hydrocarbon Control Cost Effectiveness ($, 1977 tons per year)
< 10	4.5	1	450	269	181	1	0.176	4.5	972
11-24	40.7	22	9,904	5,914	3,990	22	1.591	40.7	399
25-49	31.2	30	13,505	8,065	5,440	30	1.219	31.2	224
50-99	18.7	33	14,856	8,872	5,984	33	0.731	18.7	122
>100	4.9	14	6,302	3,764	2,538	14	0.191	4.9	75

---

a. The Economic Impact of Vapor Recovery on the Service Station Industry, p. 32.

Source: Booz, Allen & Hamilton Inc.

16.5 DIRECT ECONOMIC IMPLICATIONS

This section presents the direct economic implications of implementing Stage I RACT controls to the statewide industry including availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price, state economic variables and capital investment.

16.5.1 RACT Timing

RACT must be implemented statewide by January 1, 1982. This means that gasoline service station operators must have vapor control equipment installed and operating within the next three years. The timing requirements of RACT impose several requirements on service station operators including:

- Determining the appropriate method of vapor balancing
- Raising capital to purchase equipment
- Generating sufficent income from current operations to pay the additional annual operating costs incurred with vapor control
- Acquiring the necessary vapor control equipment
- Installing and testing vapor control equipment to insure that the system complies with RACT.

The sections which follow discuss the feasibility and economic impacts of meeting the above requirements within the required timeframe.

16.5.2 Feasibility Issues

Technical and economic feasibility issues of implementing RACT controls are discussed in this section.

Gasoline service stations in several air quality control regions of the United States have successfully implemented Stage I vapor control systems.

State adoption of Stage I RACT regulations will generate additional demand for the vapor control systems for gasoline service stations. However, it is estimated that off-the-shelf systems will be readily available within the next three years.

A number of economic factors are involved in determining whether a specific service station operator will be able to implement vapor control systems and still remain profitable. These include:

- Ability to obtain financing
- Ownership—major oil company or private individual
- Ability to pass on a price increase
- The current profitability of the service station
- Age of the station.

A major finding in a study on gasoline service station vapor control was that small service stations could have problems raising the necessary capital to purchase and install vapor control equipment. The inability to raise the necessary capital to install vapor control equipment may cause the closing of some service stations.

Service stations that are owned by major oil companies may have better access to capital than privately owned service stations. A private service station owner may have to borrow capital from local banks, friends or relatives, whereas a station owned by a major oil company may receive funding out of the oil company's capital budget.

It is estimated that small gasoline service stations with throughput less than 10,000 gallons per month (which represent approximately 4.5 percent of the service stations in the state) will experience a cost increase of nearly 0.45 cents per gallon to implement RACT, using two point vapor balance system, whereas larger service stations will experience a much smaller cost increase.

This will put the smaller stations at a competitive disadvantage in terms of passing on the costs to the customers by raising prices. Recent experience indicates that temporary disruptions resulting from Stage I RACT control installation can have serious impacts on the service station profitability. In an interview, the Greater Washington/Maryland Service Station Association reported that several stations experienced loss of business for up to three weeks while Stage I vapor control was being installed. Service station driveways were torn up, greatly restricting

---

[1] Economic Impact of Stage II Vapor Recovery Regulations: Working Memoranda, EPA-450/3-76-042, November 1976.

access to pumps. In some instances, oil company owned service stations were sold or closed down because the oil companies did not want to expend funds for vapor control at these marginally profitable operations.

The older service stations reportedly will experience greater cost and temporary loss of business than new gasoline stations when implementing Stage I vapor control because of the more extensive retrofit requirements.

The number of gasoline service stations has been declining nationally over the past few years for a number of reasons, including a trend towards reducing overhead costs by building high throughput stations. This trend is likely to continue whether or not vapor control is required. Implementation of Stage I RACT control may simply accelerate as marginal operations may opt not to invest in the required capital costs. Sufficient data for this state are not available to quantify the magnitude of this impact.

The paragraphs which follow compare statewide costs of RACT control, in 1977 dollars, to various economic indicators.

16.5.3 Comparison of Direct Cost with Selected Direct Economic Indicators

This section presents a comparison of the net increase in the annualized cost of implementing RACT with the total value of gasoline sold in the state, the value of retail trade in the state and the unit price of gasoline.

The net increase in the annual operating cost to the gasoline service station industry from RACT represents 0.12 percent of the value of the total gasoline sold in the state. Compared to the statewide value of retail trade, this annual cost increase is insignificant. The impact of the unit price of gasoline on individual stations varies with the gasoline service station throughput. As discussed in the preceding section, the small stations, less than 10,000 gallons per month throughput, may experience an annualized cost of up to 0.45 cent per gallon of gasoline sold, whereas the large service stations may experience a smaller annualized cost increase.

16.6 SELECTED SECONDARY ECONOMIC IMPACTS

This section discusses the secondary impact of implementing RACT on employment, market structure and gasoline station operation.

Employment is expected to decline, if a number of small, marginally profitable gasoline service stations cease operation in lieu of investing capital for compliance with RACT. Based on the statewide estimate of number of employees and number of service stations, approximately three jobs may be lost with the closing of a gasoline service station. No estimate was made of the total number of service stations that may close due to RACT.

The market structure is not expected to change significantly because of Stage I vapor control requirements. The industry trend is such that there would be 50 percent self-service stations by the 1980s. The total number of stations is predicted to decline, while throughput per station is predicted to increase.

The productivity on a specific service station is expected to be slight. Fill rates for loading gasoline storage tanks may slightly decline if coaxial or concentric vapor hose connections are used.

* * * *

Exhibit 16-12, on the following page, presents a summary of the findings of this report.

Exhibit 16-12

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR GASOLINE SERVICE STATIONS IN THE STATE OF MICHIGAN

Current Situation	Discussion
Number of potentially affected facilities	Approximately 13,570 of the estimated 17,185 gasoline dispensing facilities in the state are potentially affected
Indication of relative importance of industrial section to state economy	Industry sales are $2.48 billion with a yearly throughput of 4.88 billion gallons
Current industry technology trends	Number of stations has been declining and throughput per station has been increasing. By 1980, one-half of stations in U.S. will be totally self-service
1977 VOC actual emissions	45,000 tons per year from tank loading operation
Industry preferred method of VOC control to meet RACE guidelines	Submerged fill and vapor balance

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$12.9 million
Annualized cost (statewide)	$3.0 million (approximately 0.12 percent of the value of gasoline sold statewide)
Price	Assuming a "direct cost pass-through"--less than $.0008 per gallon increase
Energy	Assuming full recovery of gasoline--net savings of 122,000 equivalent barrels of oil annually
Productivity	No major impact
Employment	No major impact
Market structure	Compliance requirements may accelerate the industry trend towards high throughput stations
Problem area	Older stations face higher retrofit costs--potential concerns are dislocations during installation
VOC emissions after control	27,156 tons per year from tank loading operation
Cost effectiveness of control	$170 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Hydrocarbon Control Strategies for Gasoline Marketing Operations, EPA-450/3-78-017.

Economic Impact of Stage II Vapor Recovery Regulations: Working Memoranda, EPA-450/3-76-042, November 1976.

National Petroleum News Factbook, 1978, McGraw Hill, Mid-June 1978.

Cost Data-Vapor Recovery Systems at Service Stations, PB-248 353, September 1975.

Human Exposure to Atmospheric Benzine, EPA Contract No. 68-01-4314, October 1977.

Reliability Study of Vapor Recovery Systems at Service Stations, EPA-450/3-76-001, March 1976.

Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001, April 1978.

Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources, PB-236 921, Environmental Protection Agency, September 1974.

Private conversation with Mr. Vic Rasheed, Greater Washington/Maryland Service Station Association.

"The Lundburg Letter," Pele-Drop, North Hollywood, California.

Revision of Evaporative Hydrocarbon Emission Factors, Radian Corporation, PB-267 659, August 1976.

A Study of Vapor Control Methods for Gasoline Marketing Operations, Radian Corporation, PB-246 088, April 1975.

Design Criteria for Stage I Vapor Control Systems Gasoline Service Stations, U.S. EPA, November 1975.